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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4835

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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 71.

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See Advertisement, page 94. 1111

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See Advertisement page 55, Dec. 28. 3402

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See our Illustrated Advertisement, Dec. 14.

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For Paraffin and Crude Oil
Sizes 1½ B.HP. and upwards
Petters Limited, Yeovil.
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Vickers-Petters, Ltd., Ipswich
See advertisement alternate weeks. 9345

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Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 1675
See half-page Advertisement, page 68, Dec. 21.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 1311

The Institution of Civil ENGINEERS,

The Council of the Institution of Civil Engineers desire to make it known to the Public that, under new Bye-laws approved and allowed by H.M. Privy Council, in accordance with the Supplemental Charter recently obtained, Members and Associate Members of the Institution of Civil Engineers are, and are entitled to describe themselves as, "Chartered Civil Engineers." C 496

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THURSDAYS, from Seven to Ten p.m., commencing JANUARY 17th, 1924.

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A Course of Six Lectures by: WALTER ROSENHAIN, D.Sc., F.R.S., G. H. BAILEY, D.Sc., Ph.D., D. HANSON, D.Sc., GEORGE MORTIMER, A. G. GWYER, B.Sc., Ph.D., and GUY D. BENGOUGH, M.A., D.Sc.,

FRIDAYS, from Six to Seven p.m., commencing FEBRUARY 1st, 1924.

Details of the above Courses may be had upon application to the PRINCIPAL. C 484

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Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 1723

TENDERS.

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for :—

4000 LASHING CHAINS.

Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, London, E.C.2, on or after 28th December, 1923.

A fee of £1 will be charged for the Specification, which is NOT returnable.

Tenders must be submitted not later than NOON, on Thursday, 10th January, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
R. C. VOLKERS,
Secretary. C 478

STATE ELECTRICITY COMMISSION OF VICTORIA.
Melbourne,
VICTORIA,
AUSTRALIA.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification will be available upon application to:—
AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C.2.

SPECIFICATION No. 24/4.—
4 ONLY 100 K.V.A. 25,400-6600 V. TRANSFORMERS, AND SPARES.

CHARGE:—10/- for the first two copies of Tender Form, Conditions of Contract and Specification complete. This charge will be returned on receipt of a *bona fide* Tender. A third copy and any further copies will be supplied for the sum of 5/- each. This charge is not returnable.

PRELIMINARY DEPOSIT:—A Preliminary Deposit of £10 is to be lodged with Tender.

The Specification may be inspected at the above-mentioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne not later than Five p.m., 11th February, 1924.

H. LIDDELOW,
Secretary. C 440

The Director-General,

INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E.1, REQUIRES:—

GIRDERS.

Tenders due on the 29th January, 1924.
Tender Forms obtainable from above. C 517

COUNTY BOROUGH OF SALFORD.
GAS DEPARTMENT.

Tenders are Invited for the

CONSTRUCTION of RAILWAY SIDINGS, including Excavations, all Materials and Labour.

The work will be carried out under the conditions laid down by the Unemployment Grants Committee.

The Drawings may be seen, and copies of the Specification and Bill of Quantities obtained, on application to the Gas Engineer, Gas Offices, Bloom Street, Salford. C 476

L. C. EVANS, Town Clerk.

METROPOLITAN BOROUGH OF HAMMERSMITH.

ELECTRICITY DEPARTMENT.

TO MAKERS OF COAL DRYERS.

Prices and Particulars

REQUIRED
for
COAL DRYING APPARATUS,
capable of dealing with about 10/15 tons per hour.—Send details to G. G. BELL, Borough Electrical Engineer, Electricity Works, 65, Fulham Palace Road, W.6. C 489

COUNTY BOROUGH OF PRESTON.

ELECTRICITY DEPARTMENT.

The Electricity Committee invite

Offers for the Purchase and

REMOVAL of the undermentioned STEAM ENGINES and DYNAMOS, which may be inspected at the CROWN STREET POWER STATION, PRESTON:—

One Belliss and Morcom Triple Expansion Engine, 450 r.p.m., 290 B.HP., coupled to two D.C. Dynamos, each 225/240 Volts, 420 Amperes, by Electric Construction Co., Ltd.

One Willans and Robinson Triple Expansion Engine, 270 r.p.m., 395 B.HP., coupled to one 500 Kw. D.C. Dynamo, 440/500 Volts, 1,020 Amperes, by Electric Construction Co., Ltd.

One Surface Condenser, with Air Pump, &c.

Further particulars on application to the BOROUGH ELECTRICAL ENGINEER, 118, Fishergate, Preston. C 504

HERMITAGE DAM, JAMAICA.

Tenders will be received

at the Office of the COLONIAL SECRETARY, JAMAICA, for the CONSTRUCTION of a CYCLOPEAN MASONRY DAM and contingent works required in connection with the extension of the Kingston and St. Andrews Water Works.

Drawings can be seen and copies of the contract documents can be obtained at the office of THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W.1, between the hours of Ten a.m. and Four p.m.

Tenders must be addressed to the COLONIAL SECRETARY, JAMAICA. British West Indies, so as to reach him not later than 1st March, 1924. C 511

CLYDE NAVIGATION.

DOCK NO. 1, SHIELDHALL, GLASGOW HARBOUR.

The Trustees of the Clyde Navigation invite

Tenders for the Construction

of about 1928 lineal yards of CONCRETE QUAY WALL, forming Dock No. 1, Shieldhall, Glasgow Harbour, to be founded partly on a substructure of concrete monoliths and partly in open piled trench.

The Specification and Schedule and Form of Tender can be obtained at the Engineer's Office here, on and after Friday, 4th January, on payment of a deposit of £10, which will be returned on receipt of a *bona fide* Tender.

An assistant engineer will meet intending Offerers on Monday, 7th January, at Eleven a.m., at Maxwell Road, Shieldhall, to point out the situation of the Works, and subsequently as may be required.

Sealed Tenders, marked "Tender for Dock No. 1, Shieldhall," are to be lodged with the undersigned not later than Noon of Monday, 28th January next.—The lowest or any Tender may not be accepted.

T. R. MACKENZIE,
General-Manager and Secretary.
16, Robertson Street, Glasgow.
28th December, 1923. C 483

ADMINISTRATIVE COUNTY OF LONDON.

ELTHAM SEWER.

The London County Council invites

Tenders for the Construction

of an 8 ft. 0 in. internal diameter SEWER in Brick and Iron, of a total length of about 2¾ miles with Weir Chamber, Side Entrances, Manholes, etc., in the Metropolitan Boroughs of Woolwich and Greenwich.

Persons desiring to submit Tenders may obtain on and after Friday, 4th January, 1924, the Form of Tender, etc., on application to the Chief Engineer, at the Old County Hall, Spring Gardens, S.W.1, upon payment of the sum of £10. This amount will be returnable only if the Tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application and the contract documents may be inspected before the payment of the fee.

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.W.1, after 12 Noon on Tuesday, 29th January, 1924, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council. C 487

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, Copthall Avenue, London, E.C.2, invite

Tenders for:—

	FEE.
1. MISCELLANEOUS ARTICLES AND MATERIALS	7s. 6d.
2. CARRIAGE DOOR HANDLES, HINGES, BOLTS, Etc.	5s.
3. W.I. TIE BARS, for C.I. Pot Sleepers	5s.
4. STEEL FISH PLATES	£1
5. STEEL FISHBOLTS	10s.

Tenders are due by Eleven a.m. on 18th January, 1924. Tender forms obtainable at above address. FEES NOT RETURNABLE. C 533

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for :—

(A) LAMINATED BEARING SPRINGS,
(B) VACUUM BRAKE PIPE COUPLINGS.

Specifications and Forms of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, E.C.2, on or after 3rd January, 1924.

For each copy of the Specification (A) a fee of 20s. will be charged, and for each copy of Specification (B) a fee of 10s. will be charged, which fees are NOT returnable.

Tenders must be submitted not later than NOON on Monday, 14th January, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
R. C. VOLKERS,
Secretary. C 512

PORT OF BRISTOL.

FLOATING PNEUMATIC ELEVATOR.

The Docks Committee are prepared to receive

Tenders for the Construction

of a FLOATING PNEUMATIC GRAIN ELEVATOR, to handle 150 tons per hour, erected at the Avonmouth Docks, Bristol.

On and after Monday, the 7th day of January, 1924, a copy of the Form of Tender, General Conditions, Specification, Schedule of Prices, and a copy of the Contract Drawings can be obtained from the undersigned on production of a receipt showing that a deposit of £5 has been paid to the Bristol Docks Committee, 19, Queen Square, Bristol, to whom all cheques must be made payable. The deposit of £5 will be returned hereafter to all *bona fide* Tenderers.

Tenders must be enclosed in a sealed envelope, endorsed "Tender for Floating Pneumatic Elevator," and addressed to the General Manager and Secretary of the Docks Committee, 19, Queen Square, Bristol, and must be delivered to him, accompanied by all the prescribed documents and drawings, before Ten a.m. on Monday, the 18th day of February, 1924.

The Docks Committee do not bind themselves to accept the lowest or any Tender.

THOMAS A. PEACE,
Engineer,
Port of Bristol.

Chief Engineer's Office,
Avonmouth Docks,
1st January, 1924. C 518

APPOINTMENTS OPEN.

CIVIL SERVICE OF CANADA.

Wood Preservation

SPECIALIST, $2,700 per annum, Forest Products Laboratories, Forestry Branch, Department of the Interior, Montreal, Canada.

Full particulars and application forms furnished on application to the SECRETARY, High Commissioner for Canada, Kinnaird House, Pall Mall East, London, S.W.1, England.

Applications should be filed with the SECRETARY of the Civil Service Commission, Ottawa, Canada, not later than MARCH 1st, 1924. C486

Wanted, Thoroughly Capable

CHEMIST for Wet Process Cement Plant in India; must have had varied Cement Works experience. Salary, Rupees, 750 monthly. Apply, stating age, whether married or single, with full details of experience, and giving references, to MAXTED & KNOTT, LTD., Consulting and Cement Works Engineers, Burnett Avenue, High Street, Hull. C501

Wanted, Works Manager for

Wet Process Cement Plant in India. Must be qualified engineer and have had varied Cement Works experience. Salary, Rupees, 1500 monthly. Apply, stating age, whether married or single, with full details of experience, and giving references, to MAXTED & KNOTT, LTD., Consulting and Cement Works Engineers, Burnett Avenue, High Street, Hull. C502

Assistant Manager Wanted

for Marine Engineering Works in China. Applicants must possess thorough technical and also practical knowledge of modern Marine Engineering. Age 35 to 40. Salary commencing £750.

Address, detailing experience and qualifications for the post, C 524, Offices of ENGINEERING.

Wanted, Man with Combined

engineering and commercial experience to take charge of Estimating and Sales Departments of a General Engineering Works in the North of England. First-class references required. Age not less than 35. Preference to public school man.—Address, enclosing photo, stating age, experience and salary required, C 516, Offices of ENGINEERING.

Wanted, Engineer Experi-

enced in purchase of second-hand machine tools. Good prospects for smart man of good address.—Address, giving fullest particulars of experience, stating age, C 505, Offices of ENGINEERING.

STATE RAILWAYS OF VICTORIA, AUSTRALIA.

ASSISTANT CHIEF ELECTRICAL ENGINEER.

Applications are Invited

by the VICTORIAN RAILWAYS COMMISSIONERS for the above POSITION.

SALARY £1000 per annum.

Applicants must pass Medical Examination.

Applicants must be capable of successfully handling all engineering and operating matters connected with railways, electrified systems, preparing proposals, alterations and extensions; also erection and maintenance of electric power and lighting installations throughout Railways.

Applicants should give full name, age, place of birth, details of Engineering and Administrative qualifications and practical experience on electrical railways, with copies of references.

Applications, in sealed envelopes, marked "Application for position Assistant Chief Electrical Engineer," should be addressed to the SECRETARY, Victorian State Railways, Melbourne, Australia, direct, and must reach him, on or before 31st March, 1924.

On behalf of the Victorian Railways Commissioners,
JOHN McWHAE,
Agent-General for Victoria (Australia),
Victoria House,
Melbourne Place, C 469
Strand, London, W.C. 2.

TO CONCRETE ENGINEERS.

Required on a Technical

Staff the SERVICES of QUALIFIED ENGINEERS having experience in concrete construction, especially in concrete roads and bridges. They must be capable of interesting surveyors in this form of construction and giving practical advice. Salary according to qualifications, but not less than £500 per annum. The selected applicants will be required to reside in Glasgow, Manchester or Birmingham districts.

Applications will be treated in strict confidence and should be addressed in the first instance, C 479, Offices of ENGINEERING.

MINISTRY OF TRANSPORT.

Applications are Invited

for an APPOINTMENT as PERMANENT ASSISTANT ENGINEER in the Roads Department of the Ministry of Transport at a commencing salary of £200 per annum plus bonus, on the scale £200—£20—£500, plus bonus, which is subject to revision according to the cost of living index figure. The present bonus on £200 is £108 2s. per annum. Assistant Engineers are eligible for promotion to the class of Engineering Inspectors on the scale £600—£25—£800 plus bonus.

The selected candidate will be required to serve a two years' probationary period.

Candidates should be Corporate Members of the Institution of Civil Engineers or should hold some equivalent professional qualification. Experience of Road and Bridge Construction is essential, and experience in the service of Highway Authorities is an advantage. Candidates should be not more than 35 years of age, and should have served in His Majesty's Forces.

Forms of application can be obtained from the Establishment Officer, Ministry of Transport, 6, Whitehall Gardens, S.W.1.

Applications can only be received on the recognised forms and should reach the Ministry of Transport on or before the 15th January, 1924. C 466

BOARD OF TRADE.

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ENGINEERING.

THE ELEMENTS OF THE LANCHESTER-PRANDTL THEORY OF AEROPLANE LIFT AND DRAG.

EXPERIENCE with bodies exposed to the flow of a real fluid has led us to distinguish between what are commonly known as "stream-line forms" and others less fairly shaped, which offer accordingly a very much higher resistance to motion through the fluid. The essential characteristic of a stream-line form is that the stream lines close in behind the body without the formation of any "dead water" space. In the case of a perfect fluid this closing in of the stream lines occurs whatever the form of the body, so that we may say that in a perfect fluid all forms are stream line forms, and no discontinuity in the shape of a "dead water space" is to be found behind any obstruction. We can therefore (theoretically at least) calculate the velocity of flow and direction of motion at every point of a perfect fluid streaming past an obstacle of any form. It seems a legitimate inference* that the motion of an actual fluid round a stream line form cannot differ much from the motion of a perfect fluid round the same form, at any rate in regions where the shearing stresses between adjacent layers of the fluid are so small as to be negligible.

By definition a perfect fluid is incapable of transmitting any shearing force, and the "principal stresses" at any point are all equal to one another, or in other words the pressure at a point is uniform in every direction. Real fluids differ from perfect fluids in that under certain conditions shearing stresses may exist in them—in other words, they are viscous fluids. The peculiarity of shear stresses in a fluid is that their intensity depends upon the rate at which a layer of fluid slides over its neighbours. Hence when there is no relative motion between adjacent layers, there are no shear stresses, and where the relative motion is very small the shear stresses will also be insignificant. When this condition is satisfied, there is nothing inherently unreasonable in assuming that the actual fluid moves in the same way as would a theoretically perfect fluid and subsequently trying out how this hypothesis fits in with actual observation. An aeroplane wing is a stream-line form, and under normal conditions the lift is very large in comparison with the drag. As a first approximation we may accordingly neglect this drag, and concern ourselves solely with the mechanism by which the lift is produced. Now it is obvious that the physical conditions must be the same, whether we regard an aeroplane as moving through still air or whether we regard it as stationary and the air streaming past it. The character of the flow is most easily visualised in

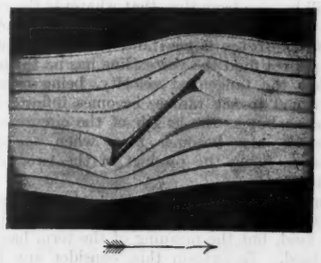


FIG. 1.

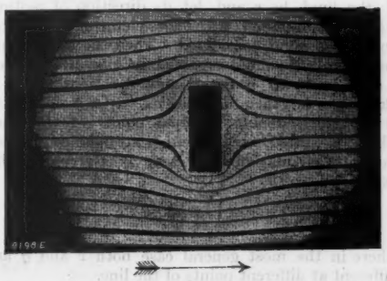


FIG. 2.

the latter case, and a little consideration will show that at a distance from an aeroplane the velocity of a stream line measured relatively to that of an adjacent stream line becomes vanishingly small. Shearing stresses accordingly disappear, and outside of this limit we shall assume that the flow is indistinguishable from that of a perfect fluid.

In the region in which this state of affairs subsists let us conceive an imaginary boundary, lying within which is not only the aeroplane but also all the air which is not moving as a perfect fluid would move. Outside this boundary the actual fluid can be replaced by a theoretically perfect fluid, and the latter is not subject to friction at a solid wall. Hence as a further step we may consider that the fluid inside the boundary is solidified without changing its specific gravity. Such a solidification may, of course, alter the stream lines in the immediate neighbourhood of the boundary, but at a distance from this, the flow will be sensibly the same as before the solidification was effected. In the original state of affairs the weight of the aeroplane was supported by the moving fluid, being transferred from layer to layer till a region was reached in which the motion was sensibly the same as that of a perfect fluid. At a sufficient distance this flow will be unchanged by the imaginary solidification. Hence we have therefore a solid body containing in its midst a heavy aeroplane, and supported by the flow past it of a perfect fluid. Now, it is well known that a solid immersed in a perfect fluid which is at rest will, on having been once set in uniform motion along a straight line, experience no resistance. This curious paradox formed the subject of some interesting communications to *Nature* by the late Mr. W. Froude during the autumn of 1875. The mathematical proof is not difficult, but for the present we shall merely illustrate the point by Figs. 1 and 2, which are reproductions of two of Prof. Hele-Shaw's photographs showing stream line motions in a perfect fluid. Here it will be seen that the stream lines on opposite faces of the obstacle are perfectly symmetrical. The velocity at any point is inversely proportional to the spacing of the stream lines, and since Bernoulli's theorem, as to the constancy of the sum of the pressure and velocity heads, applies rigidly to a perfect fluid, the identity of the distribution of the velocity on the opposite faces of the obstacle implies a corresponding identity of pressures, and hence the forces which press on the surface of the obstacle cannot at most constitute more than a couple. There will be a tendency in the case represented in Fig. 1 for the obstacle to set itself at right angles to the stream, but there will be none for it to move bodily with or across this stream. Nevertheless, actual experience shows that when a wing form is exposed to a current of air, there is quite a large force tending to make it move bodily across the current. We are thus confronted with three indubitable and apparently conflicting facts, viz. (1) that an aeroplane really is supported by the air streaming past it; (2) that at a distance from the plane the motion of the air is sensibly that of a perfect fluid; and (3) that a perfect fluid, if itself at

* This inference must not be extended to the flow of fluids through tubes, as the kind of turbulence found within pipes has no analogue in the flow of a fluid round an obstacle. In a pipe the turbulence fills almost the whole cross-section, whilst when a fluid flows round an obstacle, no turbulence can be found even at a short distance from the obstruction.

rest, exercises no resultant force on any body immersed in it. How is the apparent paradox to be explained?

It is to Mr. F. W. Lanchester that we owe both the recognition that a difficulty did exist here, and also the solution of the mystery. He pointed out in his treatise on aerodynamics published some 15 years ago that, whilst it was true that a perfect fluid, if itself at rest, exerted no force on a body moving through it in uniform motion, this was no longer the case if the perfect fluid was the seat of vortices, the cores of which abutted on the wing surfaces.* The importance of this concept lay in the fact that it provided a physical explanation of aeroplane support and of the thrust of a screw propeller, whilst up till then we had contented ourselves with a purely mathematical equation. We equated lift or thrust to the downward or rearward momentum generated, and in this way fixed proportions by empirical co-efficients.

Generally speaking, it is the Teuton, whom we regard as being content with an equation instead of with a mental image of the mechanism involved, but in this instance it was our own mathematical physicists who failed to realise the fundamental importance of Lanchester's views, and the credit for their development into a rational and practical theory of the aeroplane must be awarded mainly to Prof. Prandtl, of Munich.

The typical vortex is Rankine's free circular vortex, in which the fluid rotates around an axis with a tangential velocity which at any point is inversely proportional to the distance of the point from the axis. It may further be added that every particle of the fluid revolves round this centre without rotating on its own axis, moving, in short, much as the planet wheel of a sun and planet motion. A vortex could not be started in a perfect fluid, but if a vortex exists in such a fluid the converse proposition holds, and it cannot be destroyed. Actual fluids are not perfect, and accordingly it is possible to start vortices in them; and at a distance from the axis, the vortical motion of these imperfect fluids is almost the same as if they were free from viscosity. Indeed, this analogy may be pressed more closely, and we may say that the vortex in a real fluid differs mainly from a vortex in a perfect fluid in that in the latter the core of the vortex is a line in Euclid's sense of the word, having length without thickness. Actual fluids are not, however, continuums, but consist of discrete molecules, and hence the core of an actual vortex must always have a sensible diameter. Particles lying on this line do spin, but as above mentioned every other particle in the vortex revolves without spinning. The core of a vortex in a perfect fluid is known as a vortex line and, as stated, is a line in the Euclidean sense.

Now suppose that in a perfect fluid, motion round a vortex line be superimposed upon a uniform motion of the fluid in a given direction. Then the resultant velocity of the fluid at any point is found by the usual rule for compounding velocities and forces—we simply add graphically the velocity due to the vortex at the point, to the velocity representing the uniform translational velocity of the fluid. It will then be apparent that on the one side of the vortex core, the vortical velocity makes the resultant velocity higher than the translational velocity, whilst on the other side of the vortex core there will be a region, where the resultant velocity is less than the translational velocity. Now by Bernoulli's principle, the sum of the pressure head and of the velocity head remains constant. Hence where the velocity is increased by the addition of the vortical velocity, the pressure will be reduced and *vice-versa*, and we thus get a higher average pressure on one side of the vortex core than on the other. If, therefore, we regard the vortex line as a fixed obstacle in a perfect fluid, it is no longer true that there is no net force exerted on this obstacle.

Obviously the intensity of this force will depend upon the strength of the vortex, and it is customary to measure this strength by the "circulation" maintained by the vortex in the fluid. In the case of a Rankine vortex the term "circulation" has a very simple signification. If from the centre of a Rankine vortex we strike a circle of radius r, then the tangential velocity of the fluid along the circumference of this circle is equal to $\frac{C}{r}$ where C denotes some constant. Then the "circulation" along the circumference of

Fig. 3.

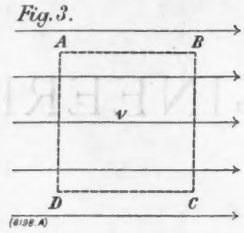
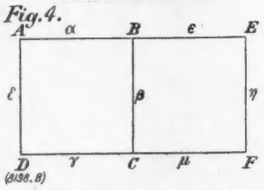


Fig. 4.



the circle in question is equal to this tangential velocity multiplied by the circumference of the circle, so that if we denote the "circulation" by Γ we have

$$\Gamma = 2\pi r \times \frac{C}{r} = 2\pi C$$

It will be seen from this, that whatever the radius of the circle taken, the "circulation" around the core of the vortex is constant. As already stated in the perfect fluid the vortex line has no thickness, and thus the tangential velocity, being inversely proportional to the radius, becomes infinite when r vanishes, but as the length of the circumference of a circle also becomes zero, when $r = 0$ the circulation, being the product of the two, is still equal to $2\pi C$.

From the foregoing it is easy to see how the function Γ came to be called the "circulation" of the fluid, but the meaning of the term has been generalised. To explain this, consider any imaginary line, curved or straight, fixed in a moving fluid. At any point of this line let the velocity of the fluid be v and let its direction of motion make the angle θ with the element Δs of the line at the point considered. Then the component velocity of the fluid resolved in the direction of Δs is equal to $v \cos \theta$ and the "circulation" along Δs is then defined as $\Gamma = v \cos \theta \, \Delta s$. If A and B denote terminal points of the line, which, as stated, may be either straight or curved, the total circulation from A to B is given by the expression

$$\Gamma = \int_A^B v \cos \theta \, ds$$

where in the most general case both v and θ are different at different points of the line.

It will be seen from the foregoing that if the line be straight the "circulation" has nothing of a cyclical character about it, and the term is accordingly not altogether a happy one. We may, in fact, have "circulation" round an aeroplane without implying thereby, that particles of the fluid circulate round the plane like planets round the sun. As will be demonstrated later the lift of an aeroplane is directly proportional to the "circulation" around it, but we would again emphasise that this term, as above stated, does not necessarily imply that the fluid rotates round the aeroplane as a centre.

Suppose the line A B along which we measure the circulation forms a closed curve, then it is easy to show that this circulation will always be zero unless one or more vortex lines lie inside the boundary considered. It is for this reason that on Prandtl's theory it is necessary to consider the vortex lines as actually attached to the aeroplane.

To prove the proposition in question consider first the case in which the fluid is in uniform translatory motion, the stream lines being as represented in Fig. 3. Take any little rectangular boundary such as A B C D, where the sides A D and B C are perpendicular to the stream lines. Then starting from A the circulation along A B is equal to A B $\times$ v, where v is the velocity of the flow. Along the line B C the velocity of flow has no component parallel to B C and the circulation along B C is accordingly zero. Proceeding along the line C D, the velocity reckoned relatively to the direction in which we are supposed to be moving round the boundary is $-v$ and the corresponding circulation is $-v \times$ C D. Along A D again there is no circulation since the motion of the fluid is perpendicular to this line. Hence the total circulation round the whole boundary is $v \times$ A B $+ (-v)$ C D $= 0$. From symmetry it is obvious that we should get the same result if the direction of the flow was perpendicular to A B instead of parallel to this line. Hence since any velocity can be resolved into a vertical and a horizontal component, the proposition holds generally. Now the area bounded by any closed curve whatever, that we may choose to imagine in the stream, can in the ultimate be considered as built up of little elementary rectangles corresponding to A B C D and as shown the circulation round each of these is zero. It is therefore also zero around the contour of any area which can be built up of these elements. It will be sufficient to prove this for a contour formed by two of these elementary squares, since if true for two, it will also be true for three, and so on.

Let the two elementary squares be as represented on Fig. 4. Let the circulation along A B be denoted by α, along B C by β, along C D by γ and along D A by δ. Similarly along B E let the circulation be ϵ and let η and μ denote respectively the circulations along E F and F C.

Then since by hypotheses the circulation around each of the elementary squares is zero, we have

$$\alpha + \beta + \gamma + \delta = 0$$

and

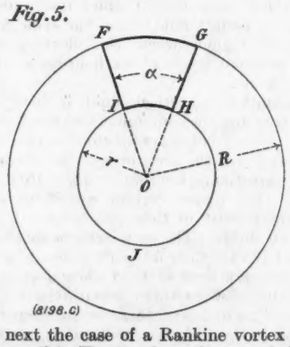
$$\epsilon + \eta + \mu - \beta = 0$$

Adding and rearranging gives

$$\alpha + \epsilon + \eta + \mu + \gamma + \delta = 0.$$

But this is the circulation around the complete contour. If we add another square to this contour and in any position the same method of proof will hold, and thus the proposition is proved for every contour.

Fig. 5.



Take next the case of a Rankine vortex such as is represented in Fig. 5, where the two circles with radii R and r respectively represent stream lines, whilst the vortex line is itself at O. Then as before consider the boundary represented by F G H I. Then the tangential velocity along F G is equal to $\frac{C}{R}$ and the length of the arc F G is equal to R a where a is the angle subtended at the centre of the circle. The circulation along F G is then equal to $\frac{C}{R} \times R\,a = C\,a$. The streamlines being perpendicular to G H there is no circulation along this line, whilst proceeding from H to I the tangential velocity reckoned relatively to the direction H to I

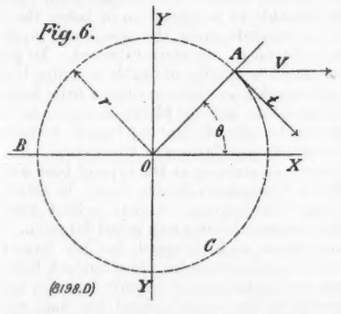
* It appears that as far back as 1897 Mr. Lanchester submitted to the Physical Society a paper setting forth this most fertile idea. Since, however, the paper was a contribution to scientific thought instead of merely to scientific data, and its author was neither a foreigner nor an F.R.S. it was summarily rejected. Joule, it will be remembered, had nearly the same experience at a British Association meeting to which he presented a paper on the Mechanical Equivalent of Heat. The chairman exhorted him to be brief, but the insight of the youthful Thomson led to a full discussion, and this most important concept thus escaped strangulation at birth. Mr. Lanchester, however, was less fortunate.

is $-\frac{C}{r}$ and the length of the arc H I is $r\,a$. Hence the circulation along H I is $-\frac{C}{r}\times r = -C$. There is, of course, no circulation along I F. Hence the total circulation around the contour is $C\,a + (-C\,a) = 0$. Now if we take any boundary whatever which does not include the point O, the area comprised within this boundary can be built up of little elements similar to F G H I and around each of these there is, as shown, no circulation. Hence there is none round the boundary taken as a whole.

If next to the contour F G H I in Fig. 5 we add the circle I J H, then there is circulation round the contour thus formed, since as already shown the circulation round the circle I H J, which now includes the vortex line, is equal to $2\,\pi$ C. We may, in fact, trace the boundary F G H J I in the following way. Starting from H we pass completely round the circle H J I back to H, and in this process we get the circulation $2\,\pi$ C. Then from H we go back to I thus cancelling the movement from I to H and having arrived at I we proceed to F G and back to H. In this second operation we have gone round the contour I F G H; along which we have already proved there is no resultant circulation, and having cancelled the journey originally made from I to H we have as a net result followed the contour H J I F G H and the circulation along this boundary is therefore the same as around the circle H I J. It will be obvious from what has gone before that the circle I H J may be taken as small as we please, but along any contour whatever which includes this circle and therefore the core of the vortex the circulation is $2\,\pi$ C.

Without for the present inquiring into the mechanism by which "circulation" is produced round an aeroplane wing, let it be assumed as a matter of fact that such a circulation exists. The question then arises as to the relationship between this circulation, the horizontal velocity of the aeroplane and the lift per unit of wing span. All actual aeroplanes are, of course, of limited span, and the ratio of this span to the fore and aft depth of the wing or wing chord is known as the aspect ratio. In the first instance it is convenient to study the purely ideal case of a wing with infinite aspect ratio moving at a constant horizontal velocity V through an infinite ocean of air. Or we can alternatively, and at times more conveniently, consider the plane as stationary and the ocean of air streaming past it. In this case we may consider that at distant points the absolute velocity of the air at any point is compounded of the translational velocity V and of the tangential motion of the fluid round a vortex line situated at the wing. Suppose in Fig. 6 that ABC represents a section of an imagin-

Fig. 6.



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ary cylinder of very large radius r described around this wing having the vortex line for its axis. Then the vortical velocity t due to this vortex line has already been shown to be equal to $\frac{\Gamma}{2\,\pi\,r}$. Then if we take a one-centimetre length of this cylinder, the flow through a little element at A subtending an angle $d\,\theta$ will be equal to $r\,d\,\theta\times$ the radial velocity of the air. From the figure it is evident that this radial velocity is V cos θ. Hence the flow through this little element is V cos $\theta\times r\,d\,\theta$ cubic centimetres per second. If ρ denote the density of the air in grammes per cubic centimetre, the mass passing per second through this little element is ρ V r. cos θ . $d\,\theta$. Now this mass leaves the contour with a certain absolute velocity, of which the vertical component is seen from the figure to be equal to $-t\cos\theta$. Hence the vertical momentum leaving at the point A is

$$-\rho\,\mathrm{V}\,r\,t\cos^2\theta\,.\,d\,\theta$$

If we integrate this expression around the whole cylinder, we shall get the difference between the vertical momentum which passes into the contour on the left and that which leaves the contour on the right. Hence, in passing through the cylindrical boundary a vertical momentum has been generated equal to

$$-\rho\,\mathrm{V}\,r\,t\int_0^{2\pi}\cos^2\theta\,d\,\theta = -\rho\,\mathrm{V}\,t\,r\,.\,\pi.$$

But (page 2)

$$t=\frac{\Gamma}{2\,\pi\,r}.$$

Hence the vertical momentum generated per second per c.m. of the length of the wing is

$$-\frac{\rho\,\mathrm{V}\,\Gamma}{2}.$$

Now, the only fixed body within our imaginary cylinder is the aeroplane, and this downward momentum must therefore be balanced by an upward force on this fixed body, which is, it will be seen, equal to $\frac{\rho\,\mathrm{V}\,\Gamma}{2}$ dynes per c.m. of wing span.

Only part of the total lift is, however due to this change of momentum. As has already been pointed out, the super-position of the circulation upon the translational motion of the air implies as a corollary that the static pressure of the air in regions below the plane is higher than in regions above it. This difference of pressure can be calculated from Bernoulli's principle, according to which the sum of the pressure head and of the velocity head is everywhere constant. Thus if p be the pressure at any point estimated in dynes per sq. cm., and if v be the absolute velocity at the same point, we have at every point around our unit cylinder

$$\frac{p}{\rho}+\frac{v^2}{2}=\mathrm{D}$$

where D is a constant.*

Now a reference to Fig. 6 shows that the vertical component of the absolute velocity v at the point A is $-t\cos\theta$, whilst its horizontal component is $t\sin\theta+\mathrm{V}$. Then the square of the absolute velocity is equal to the sum of the squares of these components. Hence

$$\begin{aligned}v^2 &= t^2\cos^2\theta + t^2\sin^2\theta + 2\,t\,\mathrm{V}\sin\theta + \mathrm{V}^2\\ &= t^2 + 2\,t\,\mathrm{V}\sin\theta + \mathrm{V}^2\end{aligned}$$

We thus get

$$p=\rho\,\mathrm{D}-\frac{\rho}{2}\,(t^2+2\,t\,\mathrm{V}\sin\theta+\mathrm{V}^2.)$$

This pressure p acts on an element of our imaginary cylinder having an area of $r\,d\,\theta$ sq. cm. The total force on this element is therefore $p\,r\,d\,\theta$ and its vertical component, measured in the positive direction of Y, is

$$\begin{aligned}&-p\,r\sin\theta\,d\,\theta\\ &=-\rho\left(\mathrm{D}-\frac{t^2+2\,t\,\mathrm{V}\sin\theta+\mathrm{V}^2}{2}\right)r\,\sin\,\theta\,d\,\theta.\end{aligned}$$

The total vertical force is equal to the integral of this expression taken over the whole cylinder. All the terms save that containing $\sin^2\theta$ lead to integrals which vanish at the limits. Hence we get for the total vertical force on the unit cylinder

$$\begin{aligned}-\rho\,r\int_0^{2\pi}\sin^2\theta\,d\,\theta &= +\rho\,t\,\mathrm{V}\,r\,.\left[\frac{\theta}{2}+\tfrac{1}{4}\sin 2\,\theta\right]_0^{2\pi}\\ &=\pi\,\rho\,\mathrm{V}\,t\,r.\end{aligned}$$

But $t=\frac{\Gamma}{2\,\pi\,r}$

Hence the lift due to the pressure difference is $\frac{\rho\,\mathrm{V}\,\Gamma}{2}$, and adding this to that due to the change of momentum we find that the total lift is $\rho\,\mathrm{V}\,\Gamma$. It will thus appear that half the total lift is due to the difference of pressure created and half due to a downward momentum communicated to the air. It will be seen that the lift vanishes if either the translational velocity or the circulation becomes zero. There is no circulation when a body passes in steady motion through a perfect fluid which is itself at rest, and thus there is no resistance to its motion.

The lift of the aeroplane accordingly depends on the fact that the skin friction generates vortices in the layers of air adjacent to its surface, and these vortices produce the circulation required. If there were no skin friction there would be no lift, and aerial transport is thus as dependent on friction as is transport by road or rail. Moreover, the vortices which are responsible for the circulation owe their existence to the motion of the fluid past the wing, so that Γ is proportional to V and the lift to V^2.

Both the upper and the lower surfaces of an aeroplane are in fact lined with a vortex sheet built up of vortex lines. In the case we have just been considering, these lines are all horizontal lines parallel to each other and perpendicular to the direction of motion. Each vortex line is generated near the leading edge of the wing and finally passes away over the trailing edge. Once clear it contributes nothing to the lift of the plane, since we can then draw a contour round the wing which does not include this vortex line, and as has been shown above, this vortex can then produce no "circulation" round the wing. The energy carried away by the vortices, which are continually escaping over the trailing edge of the wing, is equal to the work done in forcing the plane forward against its skin friction. This friction is, as already stated, small in comparison with the lift, and though the same mechanism is involved in both, the frictional force and the lift force are produced in entirely different ways.

In the demonstration given above we took the radius r as very large, because in that case the motion produced at this large radius by the innumerable vortex lines lining the wing surfaces is sensibly the same as if the whole group were replaced by a single resultant vortex line. The vortex lines formed on the upper wing surface spin in a different direction to those formed along the lower face, and the resultant circulation at any point is equal to the algebraical sum of the circulation due to each constituent, proper regard being had to whether the direction of the spin is positive or negative. Thus two parallel vortex lines of equal strength, but spinning in opposite directions, will produce no appreciable motion at distant points, since the influence of the one is cancelled by that of the other. At points near the "doublet," however, this rule, of course, no longer holds.

(To be continued.)

* In C.G.S. units it is unnecessary to introduce g.

HIGH-SPEED FORMS AND THE CURVATURE OF BUTTOCKS.

By P. G. ROUSE, M.I.N.A.

WHEN a ship is moving forward, the water has a relative motion along her after end following lines generally normal to the ship's sections, which in the case of flattened out sterns practically correspond with the ordinary buttock lines. These lines have more or less curvature according to the fullness of after body.

When a ship is stationary the forward component of the water pressure on the after body is, of course, exactly balanced by the afterward component on the fore body. As the ship gathers way, the stream at the bows being deflected causes an increase of pressure tending to retard and trim the vessel by the stern and to form the bow wave. At the after end, as the ship moves forward, the surrounding water pressure causes the water particles to fill up the space which would otherwise be left, *i.e.*, the water is given an upward and forward velocity depending upon the speed and the buttock (or diagonal) angle of the ship, this formation of velocity being accompanied by a fall of pressure on the ship's surface and consequently a drag on the ship. This drag being normal to the ship's surface has a vertical component tending to trim the vessel by the stern, and also a horizontal component which has to be overcome by the thrust of the propeller.

As the ship passes, it leaves immediately behind it water with an upward velocity; this is dissipated at the surface, where it tends to form a stern wave or local mound in the water. If the buttock (or diagonal) considered is quite straight after having turned the bilge, the water having attained a definite upward velocity depending on the speed of the ship retains this constant velocity until it reaches the

surface. If the buttock is a convex curve, the water has to be accelerated, this acceleration causing increased drag or increased work to be done on the water. In slow-moving ships the water has plenty of time to follow the contours of the buttocks or diagonals, and loses very little pressure in so doing; consequently the drag on the ship from this cause is small compared with the frictional resistance.

When, however, one considers relatively fast-moving vessels, with which this article is intended to deal, the drag is much more important, particularly in the case of rather full-bodied craft driven at speeds excessive for their lengths. As the speed increases, the acceleration required to be imparted to the water to force it to follow the buttock or diagonal lines will correspondingly increase, the pressure normal to the ship's surface will diminish and consequently the resistance to propulsion and the downward drag aft will increase.

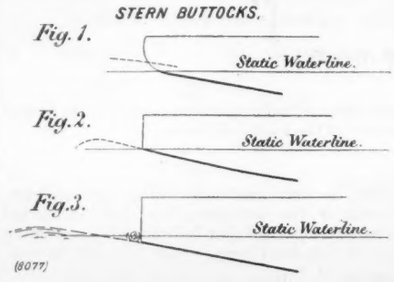
In the case of ordinary ship forms it can be imagined that if the speed be sufficiently increased there would come a time when the normal static water pressure at the stern (0·45 h lb. per square inch) would be reduced to zero, the buoyancy at the stern of the ship would have disappeared, the stern would be almost submerged, the bow would be lifted out of the water, and owing to the loss of support at the ends the ship would have sunk deeper amidships by an amount sufficient to balance the difference between this loss of support and the additional support obtained from the hydroplaning effect on the bottom, plus any additional buoyancy due to the wave formations.

The result on the water itself would be that to make it follow the ship's lines an upward and forward velocity would be imparted to the water (apart from the velocity due to friction); the more sloping and rounded the outtocks, the greater must be this velocity and acceleration, and the greater the downward drag aft. The water as it leaves the hull of the ship will continue on its upward course and form a following crest close to the stern of the ship.

The slope and round of the buttocks (or diagonals) depend obviously on three factors: (1) The length of after body; (2) the prismatic coefficient of after body; (3) the skill of the designer.

If a buttock line is ended as in Fig. 1, the line rounding up at the static waterline, as, for instance, in a full-bodied cruiser stern, it is evident that at excessive speeds, when the effect of squatting already described takes place, the waterline may have risen to the dotted position. Then a particle of water travelling along the hull will, when it reaches the original static water line, either have to break away from the hull or else turn a quick curve. Being close to the surface the pressure must be nearly atmospheric, and as the particle reaches the quickly curving part, if it separated from the hull, the initial space left between the particle and the hull would be very small, and the air which would try to get down to fill it would lose part of its pressure in getting down past the rushing water. Hence the water would initially tend to follow the turn of the hull, losing pressure (and causing a drag) in doing so, and the same effect would continue in the ensuing instant at the next point on the curve. Moreover, the surface tension between the water and the hull would assist in bringing about the same result.

The greater the speed of the boat, the higher will the water be sucked up round the curve. At speeds moderate for the length and displacement this effect would scarcely exist, the water having no difficulty in leaving the hull on reaching the surface, but in the case of a vessel with a rounded stern driven at an unsuitably high speed, a considerable adverse drag would be caused.



If, instead, the line ended with a square knuckle as shown in Fig. 2, at low speeds the alteration, being at the water line, would not affect the resistance. At high speeds the particle, on reaching the edge, could not by any means turn the corner, and, moreover, air could easily get down to it. The particle shoots away therefore at a tangent to the hull, and tends to form a crest in rear of the stern, the position of the crest depending on the speed and the mean slope of the stern lines.

Carrying the alteration further as in Fig, 3, the knuckle being placed below the static water line, it is clear that the designer can by this means reduce the slope of the buttocks without sacrificing displacement. At slow speeds the water will have time to be pressed round to the transom at the surface and fall down to the knuckle, forming a revolving low-pressure eddy which will cause more drag than with the curved stern of Fig. 1.

At high speeds the effect will be the same as for Fig. 2, but the decreased slope of the stern lines will cause the crest to retreat further from the stern of the boat, provided the speed is sufficiently great.

This space or depression in the water between the knuckle (or transom edge) and the following crest may be looked upon as the equivalent of an increase to the water line length of the ship, for one could imagine a hull extension added in that space without changing the wave formation, and so not affecting the residuary resistance though adding to the wetted surface. Thus, when the speed is sufficient, the square or knuckle stern would give better results than the cruiser stern (apart from any question of sea-worthiness). This explains the decrease of resistance obtainable in some destroyer and other high speed forms by the substitution of a knuckle for a rounded cruiser stern.

A good but exaggerated example of the space in the water behind a transom stern and of the gathering crest astern can be seen in the accompanying photographs showing a model being towed at a high speed. These photographs are taken from an article by the writer on "Suction Experiments," published in ENGINEERING, of July 6, 1923. It might also be interesting to note that on one trial of a 75-ft. motor launch during the war, when the narrow balanced rudder was put hard over at about 16 knots, it was possible to put the handle of a boat-hook down the hole formed in the water behind the rudder almost to the bottom of the rudder blade without the handle getting wet. Those motor launches ("M.Ls.") had a flat transom stern from which the rudder was hung; the transom was partially immersed when at rest; as speed increased the water boiled behind the transom, until finally it began to separate cleanly from the hull at the transom edge and shoot away astern.

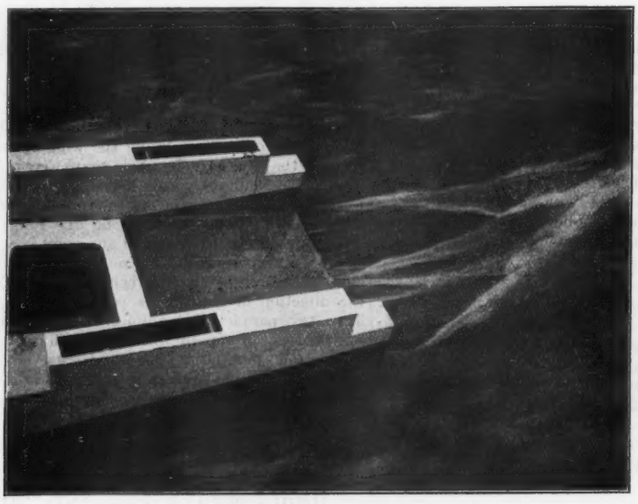


FIG. 4. STERN OF MODEL TOWED AT ABOUT 5 KNOTS.

FIG. 5. MODEL BEING TOWED AT ABOUT 5 KNOTS.

The question whether the designer should arrange for the knuckle to be placed on or below the static waterline depends upon the speed and upon the amount of trim by the stern expected. To get the best results it is usually advisable in motor boats to have the knuckle (or transom edge) a little below the static water line, and the higher the speed the lower it should be placed (having regard, however, to the broadness and flatness of the stern).

We are now arriving at the type of boat which is in effect a hydroplane, though it may be fitted with no "steps" or "chines," namely, a boat consisting of a fine entrance leading to a broad flat stern. Such a boat, driven at high speed, has her bows lifted to such an extent that her after buttock lines may become horizontal or even slightly inclined, and the depression in the water behind her may equal a considerable percentage of her length, so that the effective $\frac{V}{\sqrt{L}}$ may be considerably less than the actual (in comparison with vessels of ordinary ship form). In such boats the importance of straightness (and inclination) of buttock lines is great, as there is no time for the water to follow a curve voluntarily and if it is forced to do so a drag is caused. The static water pressure under the hull is considerably increased by the forward motion of the hull over the water, resulting in a lift which raises the boat partly out of the water. This tendency of lifting up on to the surface can be increased by the provision of the usual hydroplane step or steps underneath, or of curved side chines,

and thus we get the real so-called hydroplane boat.

The form of the buttock lines of hydroplane boat steps is very important, and the curvature for a short distance from the step must be reduced to a minimum. In the case of one of the fast 40-ft. coastal motor boats built during the war, which proved sluggish on trials, a careful examination of her bottom in comparison with an older and faster boat showed that an extra curvature of about $\frac{7}{8}$ in. in 8 ft. had been inadvertently added in the buttocks of the main step. The builders promptly had this curvature corrected, and the result was that on the repeat trials a speed of 33 knots was obtained instead of 31 knots, and the boat felt much more lively.

From what has already been described it is clearly imperative that the edge of these steps and chines (as also the transom edge) should be quite sharp. A rounded step, as shown in the profile of the original Ramus hydroplane designs illustrated in Mr. A. W. Johns' interesting article on the Ramus principle,* would cause large increases of resistance from the drag of the water ineffectively trying to turn the curve without having time to do it.

DESTRUCTIVE MARINE ORGANISMS.

A DILIGENT reader of the engineering press will probably have noticed a curious and interesting item of information in connection with the activities of marine organisms at San Francisco. The harbour authorities of that famous city in conjunction with the National Research Council have recently reported the increased activities of these organisms in their attacks on marine structures in the harbour. They state that since a destructive attack on the Dykes of Holland in the fifteenth century, the activities of marine organisms have attained a maximum at intervals of about fifty years, and at the present time one of these maxima is being experienced.

Previous observations of their destructive effect have been generally limited to timber structures, but in the present instance they are reported to have successfully attacked concrete. It has been found at San Francisco that timber piles which had been fitted with concrete jackets for their protection against certain organisms have had these jackets bored through by other organisms leaving the interior piles exposed. Some of these concrete sheathings have been found to be infested with a borer which is stated to bear the name of *pholadidea penita*. The authorities mentioned above point out that they had spent a great amount of time and money in arriving at the mixture of concrete best suited to resist the action of sea water; but they did not anticipate provision would also have to be made against the attack of marine organisms as now is shown necessary.

Some eighteen months ago a report on a similar matter was received from New York, but in this earlier report the organism concerned was the *teredo navalis* or common shipworm, whose methods and activities were better known and are restricted to timber structures. The New York authorities reported it had been found; this organism had entered the harbour, had multiplied with extraordinary rapidity, and it was recommended that for protection against their depredations, all wooden structures liable from their position to attack, should either be creosoted or treated with corrosive sublimate. The two reports indicate the increased activity of these destructive organisms.

The harbours of this country have fortunately not been greatly troubled with these pests, although reports have been received from time to time, as mentioned later, of their activities in the Southern English ports. Formerly these reports were treated lightly, it being generally understood the marine organisms concerned preferred much warmer waters than those of the English coasts, and even if present in colder waters their activities were very much decreased. Their presence in the cooler waters of Holland in the fifteenth century, however, clearly showed that given favourable circumstances they were capable of nearly as great destruction as in warmer waters.

The three reports published by the committee appointed by the Institution of Civil Engineers in 1916 to consider the deterioration of structures in sea water contain the most authoritative and complete information which has yet been collected on this most important matter. The three reports have been fully reviewed in these columns, and it is only proposed to refer to some of those portions which deal with timber and the marine organisms which attack it. The reports from San Francisco and New York referred to above are not mentioned in the volumes, but probably arrived too late for inclusion. An abstract from an earlier report from San Francisco is printed in the third volume, from which it appears the *teredo navalis*, which previously had not been found in the harbour, became exceedingly active in 1918, and up to the date of the report had continued so. It is conjectured it was brought there in the planking of ships which had been in worm-infested waters.

The first report of the committee gives additional information as to the periods of maximum activity of marine organisms in the waters of Holland. Great destruction was experienced there in 1730–32, 1770, 1827 and 1858–9, periods which coincided with abnormally low rainfalls, and consequent high salinity of the sea water. Experiments with a view to ascertain if high salinity and abnormal activity are related are being carried out in the marine laboratories. The latter are also observing this development and the habits of the teredo, together with its methods of attack on wood.

There is other information in these volumes which explain some anomalous circumstances reported many years ago in connection with the attack of wooden ships by marine organisms, and which will be referred to later. It would appear that in British waters most of the destruction of timber structures in sea water is due to the limnoria, a diminutive marine insect which destroys by the gradual attrition of the surface rather than by honeycombing the timber as is the case with the teredo. In warmer waters both limnoria and teredo are active, but the latter is the more destructive of the two.

These reports deal with stationary structures and except for one interesting reference in the introduction nothing is said as to the problem of the protection of the wooden ship against marine organisms. There are, however, several references in the detailed local reports which show that the arrangements adopted in wooden ships are still being followed with satisfactory results. They also show that some of the earlier methods advocated by a few, but strongly objected to by others, can with suitable precautions be successfully applied. The problem mentioned above was formerly a very serious one and many methods were devised for its solution. The trouble was due to the teredo, for in a moving structure such as a sailing ship, a surface parasite like the limnoria was soon swept away. Observation had shown that the teredo very rarely completely penetrated the planking of ships, but bored to within a very small distance of the inner surface. It worked in the direction of the grain and left the substance of the wood planking so completely honeycombed that its strength was greatly impaired, leading to serious leaks when the ship put to sea and was subjected to the straining action of the elements. Watertight subdivision was not then a feature in ships, and consequently any leakage beyond the capacity of the pumps—and this was not great—resulted in the sinking of the vessel. There is little doubt that in earlier times the disappearance of many ships was due to this cause. John Taylor, master shipwright at Chatham, 1652–60, and who previously had built and repaired many ships at his yard at Wapping, in a letter to the Navy Commissioners in 1654, recommended a warship going to the southward should be sheathed, and stated he knew of three merchant ships "with treasure on board enough to build a fleet of men-of-war" which had been lost by the destructive attack of the ship worm.

Dry docks in those days were few in number and ships remained afloat for long periods without docking. At intervals they were either careened or grounded for cleaning and tallowing, but these operations did not afford an opportunity for so complete and searching a survey as when dry-docked. The method of cleansing the bottom did not facilitate the discovery of worm holes, as it was carried out by the marine growth which had accumulated being burnt off by torches of burning reeds or rope yarn, thereby blackening the whole of the bottom and the white lining of the teredo holes. The latter were also generally very small on the outside of the planking.

So far as English ships are concerned the first mention of the activities of the worm occurs in 1191 when Richard I on his voyage to the Holy Land wintered at Messina. On preparing to resume his journey his ships were discovered to be much injured by the worm, which was then termed beom, and they had to be hauled up and repaired. It is not stated if any of the ships of the Mediterranean nations were at the time injured from the same cause, but it is known that long before, the Romans had used lead sheathing on their galleys for protection from the worm. In the fifteenth century a galley of the Emperor Trajan (A.D. 98–117) was discovered sunken in a lake, and her lead sheathing secured by copper nails was reported intact and in good condition. Later the Venetians are said to have used cypress wood for the hulls of their galleys, as they found it less liable to attack by the worm than other woods. It also appears they coated the bottoms with pitch.

When the Spanish and Portuguese seamen in the fifteenth century sailed into American and Indian waters on their voyages of discovery trouble with the worm was soon experienced. The Spanish followed the practice of the Romans and fitted lead sheathing. The Portuguese adopted another method and charred the outer surface of the planking, thus presenting a hard surface to the worm which it failed to penetrate. Frequently the strength of the ship was seriously impaired by excessive charring. The C.E. Report states charring is still resorted to for stationary wooden structures, especially in Australian waters, and with satisfactory results. The process, however, is more carefully applied than in earlier times, the surfaces being smeared with vaseline and charring carried out with a blow lamp. The carbo-teredo process, as it is termed, and the results obtained are described by Mr. Cunningham, the inventor, in the third report.

In 1522 the worm was reported active at Hampton (Southampton) water. In November of that year the Venetian Ambassador informed Wolsey that some galleys of his countrymen detained there were "being irreparably injured by worms." The report is interesting, as it shows that the Venetians, then a most powerful maritime community, had either made no provision in their ships against the depredation of the worm, or if arranged for, it was of little use. The C.E. Report mentions that at the present time there is little teredo activity at Southampton, but that limnoria are very destructive. It may have been the same four centuries ago, the galleys being moored and becoming for the time stationary structures.

The ravages of the shipworm were soon observed by the Elizabethan seamen in their voyages to the Spanish Main. Sir Richard Hawkyns writes, in his Observations, "Lying so long under and neere the equinoctiall lyne and towing a shallop at our sterne we found her all underwater covered with these wormes, called broma by the Spaniard and by us arters, as big as the little finger of a man on the outside of the planke, not fully covered, but halfe the thicknesse of their bodie, like to a gelly, wrought into the planke as with a gowdge. In little time if the shippe be not sheathed they put all in hazard; for they enter in no bigger than a small Spanish needle and by little and little their holes become ordinarily greater than a man's finger. The thicker the planke is the greater he groweth; yea, I have seen many shippes so eaten, that the most of their plankes under water have been like honey combes, and especially those betwixt wind and water. The entering of them is hardly to be discerned, the most of them being small as the head of a pinne."

He also states many considered the worms were bred in fresh water and brought down by the rivers into the sea. He did not agree with this, as his experience showed that fresh water fish died on entering sea water, and he considered the same would apply to the worm.

Hawkyns then describes various methods used for the protection of ships. Lead sheathing, double planking, fine canvas sheathing, charring, "betane

* ENGINEERING, September 24, 1920, page 395.

or varnish in manner of an artificial pitch" used in China, and pitch mixed with powdered glass. The most approved, he states "is the manner of sheathing used now adayes in England with their bourdes, halfe inche thicke; the thinner the better; and elme better than oake; for it ryveth not, indureth better under water, and yieldeth better to the shippes side." According to him charring was the second best method.

He then states it is the material interposed between the planking and sheathing boards which is of most importance. Describing the manner of sheathing, he writes "Before the sheathing board is nayled on, upon the inner side of it they smere it over with tarre half a finger thicke and upon the tarre halfe finger thicke of hayre, such as the whitelymers use, and so nayle it on, the nayles not above a spanne distance one from another: the thicker they are driven, the better."

Hawkyns considered the worm when boring through the hair and the tar was choked by them. He adds, this method of sheathing was invented by his father—Sir John, the celebrated seaman and Treasurer of the Navy—and experience had shown it to be the best and cheapest. The hair used was goat's hair. Sir Henry Mainwaring, in his Seamen's Dictionary (1624) gives the same description and states "the thinner the sheathing boards the better, for then the worm will presently be at the tar which he cannot abide." Hawkyn's explanation of the protective qualities of the two substances is probably correct for the C.E. Reports show tar is a good protection against the teredo, and it is also recorded that the latter rarely passes across a butt in the planking which is caulked with oakum. An Elizabethan ship sunk at Sheerness was raised in 1826 and found to have been sheathed, the goat's hair being unaffected by the long submersion.

According to other accounts, the method described by Hawkyns was employed by Henry VIII for his ships, and there are entries in his accounts relating to the purchase of goat's hair and resin which partly confirm this. Sir William Monson (1569–1643) mentions that in 1553* lead sheathing was also tried on English warships, but was not a success. Later, in the seventeenth century, the tar of Sir John Hawkyns was replaced by a mixture of tar, resin, tallow, powdered charcoal, soot and brimstone as being more poisonous to the worm. According to the C.E. Report, a protection resembling the ancient one is in use at Auckland, New Zealand. There some pontoons were built with totara planking which was first covered with felt, then with a mixture of fish oil and lime, the whole being kept in position by sheathing boards of totara ¾ in. in thickness. After eleven years in position the pontoons showed little trace of the teredo, although the waters in which they were moored were frequented by the worm.

In 1630 a report was received from Portsmouth relative to the activities of the worm in the harbour, and a Commission was sent down to investigate. The members reported finding the Triumph worm-eaten in several places but attributed this to the vessel having been moored between two East Indiamen, as no other ship was found to be similarly affected. The Commission interviewed several local seafaring men who stated sand worms were present in the harbour but they were harmless. "The art worm, which eats dangerously into ships, was not bred there," and as evidence they pointed to the piles of the blockhouse fort which had been there "time out of mind" and showed no signs of worm. Phineas Pett, one of the Commission, gave it as his opinion the report "was only a rumour raised to hinder keeping any of H.M. ships at Portsmouth."

Five years later the St. George and St. Andrew, launched in 1622, were dry docked at Deptford, and found on survey to be much worm-eaten in the keels, rudders and bows. The two ships had been lying at Portsmouth, and the master shipwrights, some of whom had served on the 1630 inquiry, concluded "there was a worm there of so dangerous a character as to hazard ships by sinking." The Navy Board thereupon recommended the bottoms and keels of ships appointed to ride at Portsmouth should be sheathed with 2-in. planks and the rudders coppered, "as was the practice with the East India Company's ships." The Board stated that if there had been a dry dock at Portsmouth—the dock formed there in 1495 had been filled in in 1620—to allow the ships to be frequently docked the planking would be unnecessary. The Lord Commissioners approved the proposals and the Triumph, Swiftsure, St. Andrew and St. George were sheathed. Three years later the Navy Board had to remind the Commissioners these four ships had been sheathed at a cost of 1,000*l.* to allow them to lay at Portsmouth, but they had been sent to Chatham and four unsheathed sent to Portsmouth. As a result the orders of Their Lordships were modified.

The change in opinion of the master shipwrights between 1630 and 1635 has been adversely commented upon, but bearing in mind later reports of the variation of the activities of the worm it is quite possible they were correct at the two dates. The C.E. Report mentions that marine organisms—the particular species is not stated—are still fairly active at Portsmouth and charring the surface of exposed timbers is being tried.

In 1650 it was decided that warships proceeding to southern waters should have their bottoms coated with a mixture of lime and tallow instead of being sheathed. This suggestion emanated from Trinity House, and appears to have been based on information given in Marco Polo's account of his travels in China and the East in the thirteenth century. "The ships of India," he stated, "are all double planked, that is they have a course of sheathing boards laid over the planking in every part. They are not coated with pitch as the country does not produce that article, but the bottoms are smeared with a preparation of quicklime and hemp, the latter cut small. With these, when pounded together, they mix oil procured from a certain tree, making of the whole a kind of unguent which retains the viscous properties more firmly and is a better material than pitch." At the present time the Chinese at Hong Kong, where the teredo is active and the majority of wooden vessels are metal sheathed, smear the bottoms of their sampans with oil. The method proposed by Trinity House was not a success and in 1654 the older method was reverted to. About this time there were numerous complaints as to the activities of the worm on British warships and many were sheathed for service with Blake in the Straits. One ship, hauled up for cleaning the bottom, was reported "so much eaten by worms that a man can see daylight in the hold."

In 1667 Sir Philip Howard and Francis Watson were granted Letters Patent for a new method of treating the bottoms of ships. The details are not stated, but the preamble mentions the disadvantages of the older method. It states, "whereas wee have byn informed that wee and divers of our subjects concerned in shipping are att great charges in the sheathing of shipps for the Streights and other forreigne parts to defend their sides from the worme, and the usual way of graveing vessels with brimstone, rozin, &c., begetts a roughnesse obstructive to sayling, &c., &c." Three years later an Act of Parliament granted the same two persons a patent for "a new manufacture, art or invencon to preserve shipps underwater which is much cheaper, more smooth and durable, than any way by deales for sheathing or pitch, tar, rozin, brimstone, or any graving hitherto used." The new method employed lead sheets and the first patent referred to the method of rolling them.

In 1671 Sir John Tippetts, Navy Commissioner at Portsmouth, reported the Nonsuch just arrived from the Mediterranean "much touched with the worm," and recommended that all ships sent on service in those waters should be sheathed with lead on the lower strakes of planking and on the keels." An Admiralty Order was immediately issued that the ancient method of sheathing was to be discontinued and lead used for the future. Twenty ships were so fitted but the method was not successful. Charles II, always interested in naval matters, keenly watched the progress of the experiment, and on the return of the Phœnix in 1673 visited Sheerness where she was docked to ascertain the condition of the lead. The new method was not in favour with Naval officers, and Sir John Narborough in command of the Mediterranean Fleet, reported in 1675 that the rudder irons of his ship, the Harwich, were rusting away due, as he thought, to the action of the copper nails with which the lead sheathing was secured. Pepys showed the report to Charles, and informed Narborough the King would suspend his opinion on the matter until he had an opportunity of inspecting ships from the station, but found it difficult to admit that "that which never becomes rusty itself (such as these nails are said to be) can communicate rust to any other matter." It was not until many decades later the explanation was forthcoming. According to the C.E. Report, lead sheathing is still used at Fleetwood where the wooden piles are first tarred, then covered with felt on the wet tar and finally sheathed with lead secured by copper nails.

The Royal Society considered the question of sheathing in 1679, but beyond suggesting it might be useful to dip the iron, copper or brass nails used for securing the lead in tin or lead, so as to well cover them, proceeded no further. In the discussion one member stated that about 130 years before a ship sheathed with lead left England for Muscovy (Russia) but from the rust of the nails the lead sheets all became detached.

On July 21, 1686, according to the Royal Society Report, "happened much discussion about the way of preserving ships from the worms, and it was remarked that sheathing with lead was the best expedient and found so by the experience of Sir Anthony Deane, but that the carpenters, finding it against their profit, opposed it by affirming that the iron of the pintles of the rudders of ships so sheathed were much more apt to be corroded by the sea water than those sheathed with wood, which yet was a groundless supposition." Pepys, President of the Society that year, was absent or might with his knowledge of the Narborough reports have corrected the statements. John Evelyn, who was present, suggested japanning or lacquering the planking might be a very good preservative" but it was objected the working of the ship would crack the varnish and the worm would enter."

In 1682 the Navy Board had reported against the further use of lead sheathing and the older method was again used, ships going to the Mediterranean and West Indies being so fitted. In 1708 copper sheathing, as used previously for the rudder only, was suggested but the naval authorities rejected it as being too expensive and requiring too great a time to put on and take off. In 1717 the gates of a dock or basin at Portsmouth yard were copper sheathed, but this appears to have been the only instance in which the metal was used. In May, 1725, Benjamin Robinson and Francis Hawksbee were granted letters patent for a new method of sheathing and preserving plank, which consisted of rolled copper, brass, tin, iron or tin plates or a composition of either or all these. Alternatively they had a composition for use on the bottoms of ships which became hard and tough after application and protected the planking from the worm.

In 1759 copper sheets were tried on the keels and sternposts of some ships, and proving successful it was decided in 1761 to sheath the bottom of a small frigate—the Alarm—with the same material, as an experiment. The sheets were of 12 ounce copper secured to the planking by copper tacks along the edges. On docking, after two years' service in the West Indies, it was found the copper had been successful in keeping out the worm, and had maintained the cleanliness of the bottom but some of the sheets had worn through. Further experience showed that the iron fittings on the rudder and also the iron bolts securing the planking were extensively oxidised. Two other ships were copper sheathed in 1769, and great care was taken in these to prevent metallic connection between the copper sheathing and the iron bolts, but the oxidation was not stopped, and to remedy this it was decided early in 1783 to use mixed metal in place of iron

* Monson's remark is evidently based on an account given in Hakylut's Principal Navigations (published in 1589) of Richard Chancelor's Voyage to Muscovy (Russia) in 1553. It is there stated one of the ships they made "stanch and firme by an excellent and ingenious invention. For they had heard that in certain parts of the ocean, a kind of wormes is bredde, which many times pearceth and eateth through the strongest oake that is; and therefore that the mariners and the rest to bee employed in this voyage might be free and safe from this danger, they cover a piece of the keele of the shippe with thinne sheets of leade."

bolts, and later in the same year copper bolts were ordered. This was an expensive alteration—the extra cost for bolts in a 90-gun ship being slightly over 2,000*l.*—and at one time the Navy Board seriously considered the discontinuance of copper sheathing.

In view of the expense other and cheaper substitutes were suggested and tried. In spite of its previous failures, lead sheathing was fitted to two ships but without success, one of the ships when docked was found to have lost nearly the whole of the lead. Zinc sheets and also some of a mixture of tar and zinc were also tried and failed. Metal nails with large flat heads—scupper nails—so closely spaced as almost to completely cover the bottom were also used, but the results were not satisfactory. As a result of the various tests it was finally decided to adhere to copper sheathing, and shortly after 1783 copper sheathing and bolts of the same metal for the planking were decided on for all British warships. Lord Barham—who as Sir Charles Middleton, was Comptroller of the Navy from 1778 to 1790—stated the adoption of copper sheathing virtually doubled the effective strength of the British Navy.

As an illustration of the value of sheathing, or rather the danger attending on its omission, it is recorded that in 1807 the 74-gun ship Sceptre left Bombay for England, but developing a serious leak had to return. On being docked and surveyed it was discovered a few sheets of copper had become detached, and the teredo had entered the uncovered planking and bored away sufficient material to cause the leak.

Further experience with the copper sheathing showed that it gradually decreased in weight, and the naval authorities were seriously disturbed at the loss and consequent cost of renewal. It was not, however, until 1823 steps were taken to obtain a remedy. The Royal Society was consulted, and Sir H. Davey suggested the fitting of cast iron protectors in suitable positions on the bottom. These were tried and it was found that whilst the waste of copper was obviated, the bottom soon became covered with marine growth which seriously reduced the speed of the ship. The copper had ceased to expoliate and thereby to keep the bottom clean, one of its chief advantages as a sheathing material. The cast iron protectors were discarded and the gradual waste of the copper accepted. Trials with various materials—white lead and cartridge paper, then felt and tarred paper—between the copper sheathing and the planking showed that the last named material was the best, and it has remained in use for the purpose since.

The patent records between 1767 and 1850 give details of many proposals for a sheathing material cheaper than copper. Powdered glass, treatment of the planking with calcium salts, mineral oil and tar, bitumen, sheets of various mixtures of zinc, lead, antimony iron and copper were all suggested and probably tried. Muntz metal was patented in 1832 and 1848, the first mixture consisting of from 50 to 63 parts of copper and 50 to 37 of zinc and the later of 56 copper, 40¾ zinc and 3¼ of lead and this has been the only serious rival to copper. Its cheapness and efficacy caused it to be used in merchantmen in place of copper. The C.E. Report mentions muntz metal as being used for sheathing timber structures in several Australian and New Zealand ports, but in recent years the quality has deteriorated and the useful life reduced as compared with that supplied before the war. Copper has been used for sheathing piles at Jamaica, and the only drawback to its use has been its frequent theft.

The adoption of iron for the structure of ships removed all danger of damage from the teredo, and although iron and steel warships intended for service in Far Eastern waters had to be wood-sheathed and coppered, this practice was discontinued as soon as the necessary docking facilities were available. One interesting chapter in the fight against the depredations of marine organisms has thus been brought to a close, but not, as may be concluded from the preceding account, without the expenditure of a considerable amount of time, labour and money. It may be the case that with some of these organisms successfully attacking concrete, as reported from San Francisco, another chapter is being opened. If so, the far greater resources of knowledge now available should render it a shorter one than that which deals with the steps taken to protect wooden ships. For such purposes the information contained in the Reports of the Institution of Civil Engineers Committee should prove of inestimable value.

YEAR BOOKS AND ANNUALS.

The South Wales Coal Annual, 1924.—A very interesting and useful annual for all firms who are interested directly or indirectly in the coal trade is the one having the above title; it gives a large amount of information in that trade in all its phases. It contains a large number of tables on coal prices, output and shipments over several years, with other information of a commercial nature. Separate chapters deal with coke and with by-product coking in the South Wales coalfields; with pit-wood, &c. A directory of the South Wales and Monmouthshire collieries is also given, the information under this heading including the owners' names, the commercial offices, colliery names, kind of coal produced, railway station, &c. A special section covers miners' wages and acts and agreements regulating them. The book is edited by Messrs. C. P. Hailey and D. Willson Lloyd, and is issued at the price of 12*s.* 6*d.* net by The Business Statistics Company, Limited, Baltic House, Cardiff.

Year Book of Wellington Harbour Board, New Zealand.—This year book gives a history and a description of the Port of Wellington, with particulars of the facilities it offers. The labour-saving appliances on wharves and in sheds are entered into, also the various charges made for all classes of goods. All ordinary repairs to wooden and iron vessels, and to engines and boilers, can be effected at Wellington. Tables give the trade of the port, receipts and expenditure, &c., over several years. The harbour has a total area of 20,000 acres, and the foreshore line a length of 32 miles. The book is carefully illustrated with views and plans. In sending it us, the Board desires to bring under notice its exhibit in the New Zealand section of the British Empire Trade Exhibition to be held in London this year, and invites inspection of the photographs, plans and other descriptive data which it is going to display.

"*Ice and Cold Storage*" *Directory*, 1924.—The first part of this directory and handbook for the present year, the nineteenth edition, contains a large amount of technical data in tabular form connected with cold storage. This is followed by information on recent patents granted in the same field; particulars as to the new companies registered since August, 1922; lists of cold stores giving their capital, capacity, system used; directories classified under names and under specialities. The book appeals to all connected with the refrigerating industry and allied trades, and is issued by Messrs. Iliffe and Sons, Dorset House, Tudor-street, E.C. 4, at the price of 10*s.* 6*d.*

The Electrical Contractor's Year Book, 1923–24.—The Electrical Contractors' Association (Incorporated), 15, Savoy-street, Victoria Embankment, W.C. 2 (price 2*s.* 6*d.*) This yearly volume gives the names of the member firms constituting the association, together with a history of the association and a sketch of its activities. A large part of the book is made up of copies of the working rules, governing hours, wages, &c., in the various districts over which membership of the association is divided. The book is an essential one for electrical contractors, and contains much of value for consulting engineers, architects and others.

VENTURI METER FOR PULSATING FLOW.

THE impossibility of operating a boiler plant at its maximum efficiency without some means of knowing how much water is evaporated, shift by shift, in return for the fuel burnt is now becoming generally recognised, and of all the forms of water-meter available for the purpose the Venturi probably combines most of the features which the engineer desires. The Venturi tube requires no space to be found for itself, as it merely replaces a corresponding length of the feed-line, and the instrument can be situated in any reasonable position. The meter will work under full boiler pressure, and it can be made to indicate on a dial the rate of flow at any moment, to register the total number of gallons or pounds of water passed, and to record on a chart the rate of flow over a period. The same instrument will do any or all of these things, and there is, we believe, no other type of meter on the market with so wide a scope of application. In spite of these great advantages, however, the Venturi meter, as generally constructed, has suffered from a very grave defect, namely, an inherent inaccuracy when the flow is of a pulsating character. When measuring the water delivered by a simplex direct-acting pump, for example, the readings may be anything up to 12 per cent. greater than the true quantity of water flowing, and with two or more pumps running more or less in step, the error will be of the same order of magnitude. It seems practically impossible to reduce the error substantially by even the largest air-vessels, and in consequence the meter has become suspect for the conditions which prevail in so many boiler-houses.

The all-round advantages of the Venturi principle are, however, so considerable, particularly where the large quantities of feed-water dealt with in modern power stations have to be metered, that the problem of eliminating the defect to which we have called attention was investigated by Mr. Walter G. Kent, the managing director of Messrs. Geo. Kent Ltd., of Luton, who are well known as makers of Venturi and other meters for water and steam. As a result of his experiments a new type of Venturi instrument has been developed by the firm, which appears to have overcome the one serious objection to the Venturi meter when working with a pulsating or irregular flow. The new instrument, known as the 1922 Venturi Recorder, has already proved its accuracy under service conditions which would have been fatal to the truthfulness of its predecessors of the ordinary type, but before describing it in detail we will refer to the nature of the problem which had to be solved.

If we denote by v_0 and p_0 the velocity and pressure at the entrance to a Venturi tube, and use v_t and p to denote the same quantities at the throat of the meter we have by Bernouillis theorem:—

$$p_0 + \frac{v_0^2}{2g} = p_t + \frac{v_t^2}{2g}$$

whence

$$p_0 - p_t = \frac{v_0^2}{2g}(r^2 - 1)$$

and

$$v_0 = \sqrt{\frac{2g}{r^2 - 1}} \times \sqrt{p_0 - p_t}$$

in which expressions r stands for the ratio of the inlet diameter to the throat diameter.

Now we will assume the flow of the water varies harmonically, as it would do if the plunger were driven by a crank. We may therefore write

$$v_0 = V \sin \theta$$

in which V is a constant, and θ is the angle of the imaginary crank which would produce the harmonic motion. As there is no return flow of the water, the value of θ must lie between O and π.

We have then

$$p_0 - p_t = \frac{V^2 \sin^2 \theta}{2g}(r^2 - 1)$$

With the mercury throttled in the usual way, it is the mean value of this expression which determines the meter reading, or

$$\overline{p_0 - p_t} = \frac{V^2(r^2 - 1)}{2g\pi} \int_0^\pi \sin^2 \theta \, d\theta$$

$$= \frac{V^2(r^2 - 1)}{4g}$$

The meter reading is therefore

$$v_0 = \sqrt{\frac{2g}{r^2 - 1}} \times \sqrt{\frac{r^2 - 1}{2g}} \times \frac{V}{\sqrt{2}}$$

or

$$v_0 = \frac{V}{\sqrt{2}}$$

The true average flow is

$$V \int_0^\pi \sin \theta \, d\theta = \frac{2V}{\pi}$$

so that the ratio

$$\frac{\text{actual reading}}{\text{true reading}} = \frac{V}{\sqrt{2}} \times \frac{\pi}{2V} = \frac{\pi}{2\sqrt{2}} = \frac{3{\cdot}1416}{2{\cdot}8282}$$

$$= 1{\cdot}118$$

or an error of nearly 12 per cent. fast.

The problem, therefore, of measuring a pulsating flow with a Venturi meter resolves itself into that of correctly averaging the rate of flow rather than the square of the rate of flow, which latter is what the ordinary mechanism does. Mr. Kent has solved the problem in the meter, the details of which are illustrated in Figs. 1 to 14, on pages 8 and 9, in a very ingenious manner. The Venturi tube for use with the meter is exactly of the ordinary type, but it is connected to the meter by quite large pipes, so that the full fluctuation of pressure of the pulsating flow shall be transmitted with practically no friction loss. Fig. 3, on page 8, gives a section through the U-tube of the meter. In one leg of this tube is a float, which rises and falls according as the mercury level alters and operates the registering and recording mechanism.

Reference to Fig. 3 will show that the float spindle is connected to a link mechanism by means of which

VENTURI WATER-METER FOR PULSATING FLOW.

CONSTRUCTED BY MESSRS. GEORGE KENT, LIMITED, ENGINEERS, LUTON.

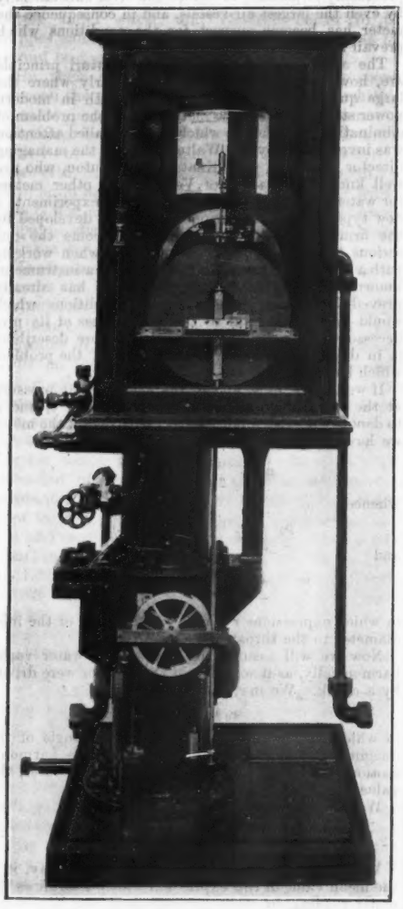
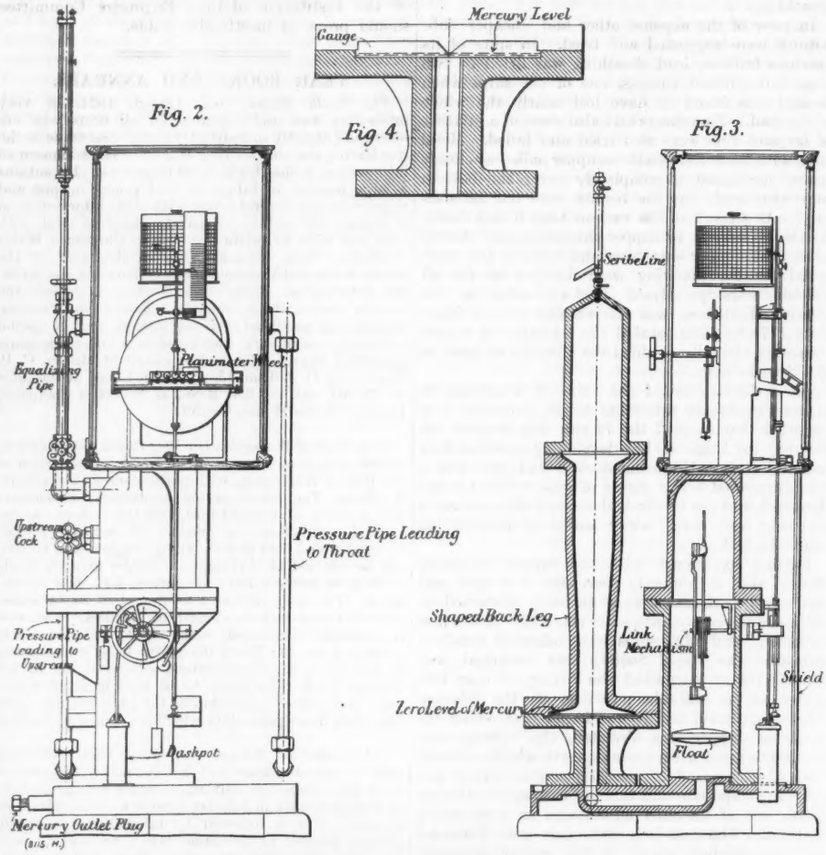


FIG. 1. METER WITH CASING PARTLY REMOVED.



its rise and fall cause the rotation of a horizontal spindle. This latter spindle passes through a gland in the side of the U-tube, and operates the external wheel shown in Fig. 5. The link-mechanism is much more clearly shown in Figs. 6 to 9, on page 9. Its object is to render the rotation of the spindle more nearly proportional to the flow through the Venturi tube, than would be the case if the float were to operate the spindle by means of a simple rack and pinion gear. The float rod is guided by anti-friction rollers, and is connected to the horizontal spindle by the jointed links, the whole arrangement being well shown in Fig. 6.

With the arrangement as so far described the result would be that the angular motion of the horizontal spindle would be much more nearly proportional to the rate of flow than if the link mechanism had not been interposed. But the linkwork alone is not sufficient to ensure perfect proportionality, especially at low rates of flow, where the difference in height of the mercury level for equal increments of flow becomes very small. Hence a further correction has to be provided, and this is obtained by shaping the back leg of the U-tube to the internal form shown in the drawing. The back leg is bored out to a peculiar shape, with a large diameter at the bottom, rapidly narrowing to a throat and then slowly diverging again. The zero level of mercury in this leg is carefully set by means of the gauge shown in Fig. 4. If the two legs of the U-tube had been of parallel bore, the rise of the mercury in one would have been exactly proportional to its fall in the other. By shaping the back leg as shown however, the mercury in the float leg will not rise and fall proportionally to the pressure difference, but will have a large motion for initial increments of pressure, and a smaller one for subsequent increments. The float, therefore, will take up a position more nearly proportional to the flow through the Venturi tube than to the pressure difference caused by that flow.

The combined result of the shaped U-tube and the link mechanism is to cause the horizontal spindle to have an angular displacement directly proportional to the quantity of water passing through the Venturi tube at any time. The spindle will oscillate backwards and forwards in unison with the pulsations, when the flow is fluctuating, as no damping device has been introduced up to this point. The front view of the damping device which is actually incorporated is shown in Fig. 10, and the plan in Fig. 11 on page 9. Its action, however, will be better understood from Fig. 12, which shows the back view. The arm A is attached to the horizontal spindle of the meter, and reciprocates with it. When this arm rises, it comes into contact immediately with the end of the lever B, and carries this lever with it. The lever B is, however, attached to the wheel D by a spring C, and the wheel is therefore pulled round against the damping action of the oil in

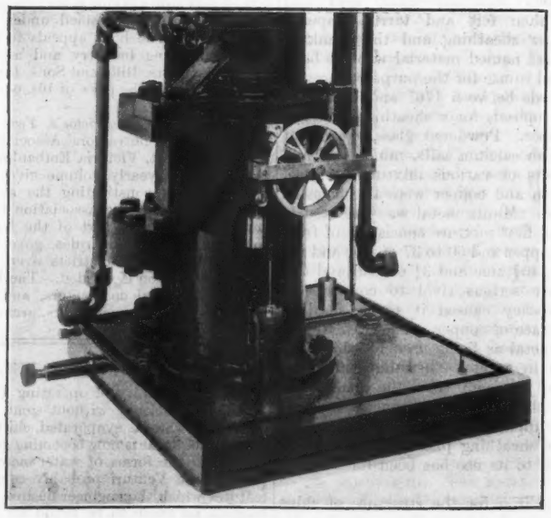


FIG. 5. DAMPING MECHANISM.

VENTURI WATER-METER FOR PULSATING FLOW.

CONSTRUCTED BY MESSRS. GEORGE KENT, LIMITED, ENGINEERS, LUTON.

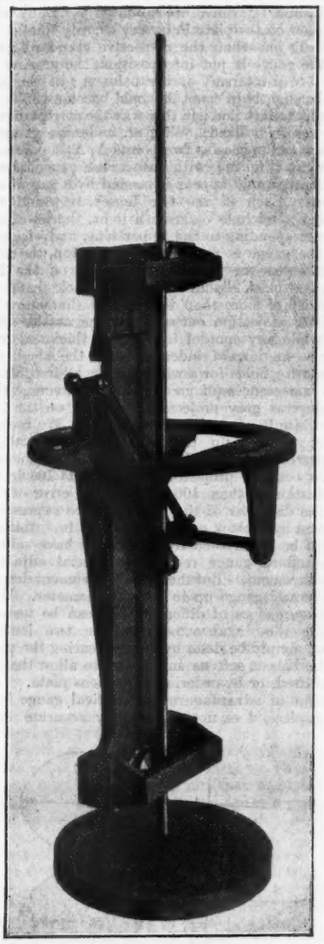
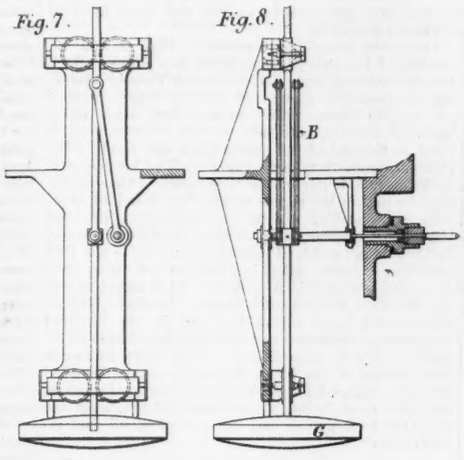
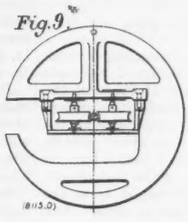
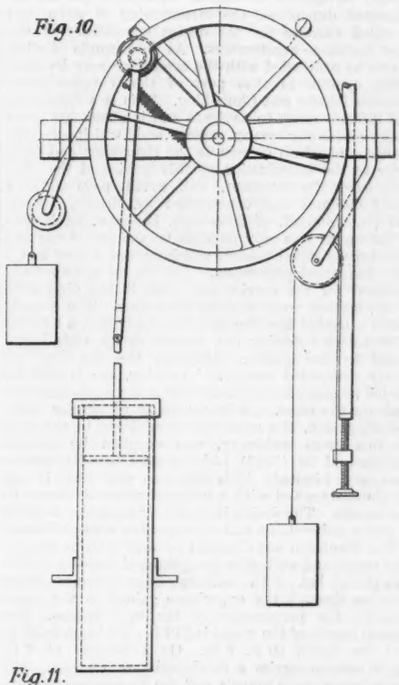
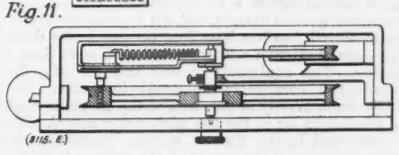


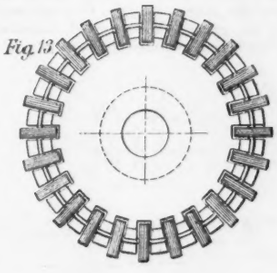
FIG. 6. FLOAT WITH LINK MECHANISM.

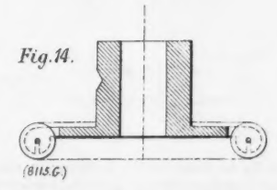


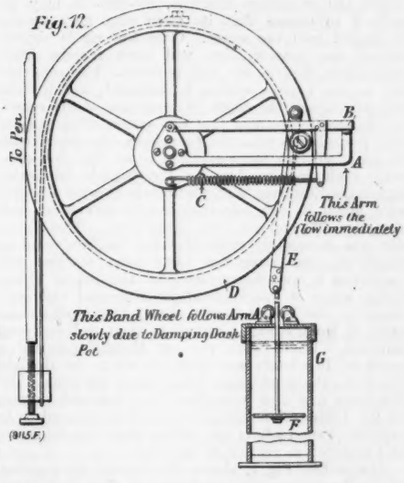












the dashpot G. The wheel can only move very slowly, and it will eventually take up a position corresponding with the average tension of the spring C, and therefore with the mean position of the lever A. The pen, being driven by the rim of the wheel, will therefore record the true average of a pulsating flow.

In addition to its recording qualities, the meter will also integrate the flow, and register on a counter the number of gallons passed. The integrating mechanism, which is shown below the recording pen in Figs. 1 and 2, is of the friction wheel type, but is so designed as to avoid the troubles which similar mechanism often gives, through the slipping of the wheel. The mechanism consists essentially of a large rubber-covered disc with its face vertical, a friction wheel being arranged to travel across the face of the disc. The friction wheel is mounted on the rod carrying the pen, so that its distance from the centre of the disc corresponds to the height of the pen above the zero line of the chart, and therefore to the rate of flow. The disc is driven at a uniform speed by clockwork. When there is no flow the friction wheel is in contact with the centre of the disc, and therefore gets no motion. When water is flowing the friction disc is moved to a radius proportional to the flow, and is thus driven at a speed required to register the quantity of water flowing. The usual trouble with frictional integrators of this kind is that the friction wheel tends to develop flats on its edge, and then it will not register correctly. In the Kent mechanism this fault is avoided by constructing the friction wheel as shown to a scale much larger than full size, in Figs. 13 and 14. Round the rim of the wheel are a large number of radial slots, each of which carries a small rough-edged roller. These rollers enable the friction wheel to be freely moved across the disc, practically without friction, and yet they cause the wheel to be driven very effectively on its own axis by the rotation of the disc. Thus there is no wearing of the disc or wheel, such as takes place when the wheel has a solid edge, and no appreciable resistance is offered to the taking up of a new position by the wheel.

The new Kent Venturi meter will record satisfactorily over a range of flow varying from 1 to 15. The ordinary recorder stands 4 ft. 6 in. high, and is usually mounted on a brick or concrete plinth to bring the diagram and counter up to a convenient level. The lower portion of the mechanism, which is shown bare in Fig. 1, can be enclosed in a cabinet, as well as the upper portion, the whole being under lock and key. The usual diagram is 4 in. high, but 6-in. charts can be provided. The length of the chart is 19 in., giving $\frac{3}{4}$ inch run of paper per hour, unless ordered otherwise. The new meter has been tested on actual service against calibrated tanks, and has shown wonderfully great accuracy. In one case, when used to measure the delivery of a centrifugal feed pump to a battery of boilers fitted with automatic regulators, the reading was within four tenths of one per cent. of the quantity measured by the calibrated tank. A test on water coming from a reciprocating pump, with ten pulsations per minute, showed an error within two per cent. as regards the counter figures, and much less than one per cent. by integrating the diagram. The second test mentioned was under conditions as severe as any meter would be called on to stand in ordinary power station practice, yet the accuracy was well within the limits which can be commercially obtained in such work. The readings of an ordinary Venturi meter under the same conditions would have been too inaccurate to be worth anything at all, and it is doubtful whether any other type of meter on the market could have given as good results as the type we have described.

CEMENT PRODUCTION IN THE UNITED STATES.—We read in *The Canadian Engineer* that the production of Portland cement in the United States in October was the largest for any month of 1923 and broke all records for a single month. It amounted to 13,350,000 barrels. For the ten months ending October 31, over 114,000,000 barrels were produced, exceeding the 1922 figure for the same period by 20,000,000 barrels.

THE SHALLOW DRAUGHT STEAMER "WANHSIEN."

THE design of ships and their propulsion machinery for the navigation of shallow waterways has always presented difficulties, the surmounting of which has provided exercise for the design capabilities of the most ingenious constructors. As an example of what has to be contended with the conditions may be cited which operate in that part of the Yangtze-Kiang between Ichang and Chungking. This is a dangerous and difficult reach to navigate and is about 400 miles long, containing many rapids and whirlpools, the positions of which change as the river rises and falls. Prior to the introduction to this service of the Shu-Hun (see ENGINEERING, vol. xcviii, page 572), a vessel designed and constructed by Messrs. Yarrow and Co., Limited, of Scotstoun, Glasgow, navigation of the rapids was only possible by the use of warping with ropes carried ashore, which proved a slow and a very dangerous proceeding. This vessel was specially designed for the service and with it the difficulties of navigation were entirely overcome. The success which attended the Shu-Hun was such that a number of steamers following the Yarrow design were introduced to the service. Although the Shu-Hun has nearly completed ten years' running, she is still regarded by many authorities as one of the most successful craft on the river. A larger vessel of similar type, the Wanhsien, the most recent addition to the fleet on this great waterway, was supplied by Messrs. Yarrow and Co. (1922), Ltd., to the China Navigation Company, Limited. This ship has now been in use for some time and with a great measure of success to her credit. The design is shown by a profile, a series of plans and sections and a perspective view on Plate I.

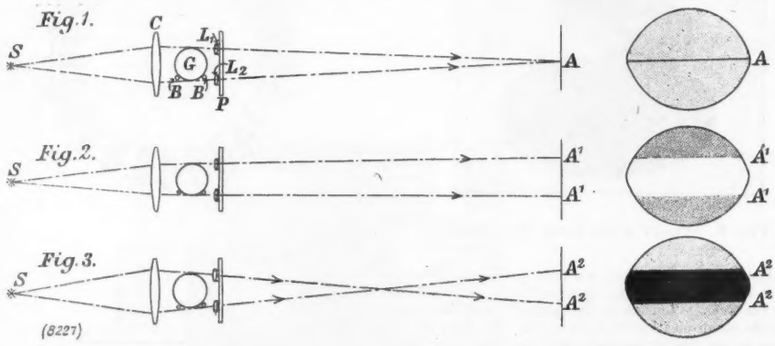
The Wanhsien was designed to carry both passengers and cargo and embodies the principal features of the Shu-Hun, but with certain improvements made possible through the experience gained in the years between the preparation of the two designs. The overall length of the vessel is 210 ft., the beam is 33 ft. and the depth 10 ft. 6 in. On a draught of 8 ft. the Wanhsien carries a deadweight of 725 tons. The propellers work in tunnels, and the Yarrow patent automatic hinged flap has been incorporated in the design to obtain maximum efficiency under all conditions of loading. This equipment ensures that the propellers always run completely immersed in water. Were simple tunnels only in use, part of the propeller might be running in air in the top part of the tunnel. This is prevented in the Yarrow system by making that part of the top of the tunnel at the after end which is behind the propellers movable, so that it may be inclined to ensure that its stern edge may always be dipped into the water. Once the air is driven out of the tunnels they will then remain filled with water, for no air can re-enter. The movable flap in the Yarrow system is balanced, and it rises and falls to suit the depth of immersion of the vessel. It is interesting to note that this system of propulsion with propellers working in tunnels in association with the balanced flap end was fitted to all the river gunboats built by the firm for the British Admiralty during the European War, particulars of some of which were given in our columns (see ENGINEERING, vol. civ, page 429 and vol. cvii, page 570). The Wanhsien was completely erected at the builders' yard at Scotstoun, and after the parts were marked and numbered it was dismantled and shipped to Hong-Kong, where it was successfully re-erected and completed by the Taikoo Dockyard and Engineering Company of Hong-Kong, Limited, in their well-equipped shipyard. Trials were run at Hong-Kong and a speed of 14½ knots was obtained when the draught was 6 ft., the deadweight being about 400 tons. The Wanhsien has now completed two seasons' running on the Ichang-Chungking reach, and has proved to be capable of successfully negotiating this very dangerous and treacherous portion of the river.

The profile, Fig. 1, shows the general arrangement of the Wanhsien with its centre and after deck structures, and the appearance of the Wanhsien in service is shown in Fig. 13. There are large holds just aft of the peak and these are served by two derricks capable of dealing with loads of 5 tons and 3 tons respectively. The profile, Fig. 1, and the main deck plan, Fig. 2, show the locations of these cargo spaces and the derricks which serve them. The third and fourth holds are aft of the engine room and two derricks, each of 2 tons capacity, are provided for loading and unloading the cargo of the larger of these. Other deck machinery consists of capstans, fore and aft, a windlass for hauling the anchor and four cargo winches. On the boat deck, Fig. 4, davits are provided for the handling of four sampans, two of which are 26 ft. long, while the others have a length of 16 ft. The after upper deck, Fig. 6, is reserved for the cabin accommodation of 26 first-class Chinese passengers and a dining saloon is provided in the middle section. At the forward end on the bridge deck, Fig. 5, there is a large wheel house and cabins for the captain, chief engineer and chief officer. Immediately below, on the upper deck, Fig. 7, there are four two-berth cabins for the use of Europeans and a dining saloon at the forward end. Provision is made on the main deck, Fig. 2, for the crew and for between two and three hundred steerage passengers.

The main propelling machinery, Figs. 2 and 10, consists of two sets of triple expansion engines which are balanced on the Yarrow-Schlick-Tweedy system and are similar to many sets built by Messrs. Yarrow for torpedo boats, mine sweepers and other naval craft. A surface condenser of the Uniflux type is fitted at the end of the engine room and receives the exhaust steam from both engines. The air pump is an independent unit of the Weir type. Other auxiliaries located in the engine room, Figs. 2 and 10, comprise a circulating pump, steering engine, fire and bilge pump, electric pump, sanitary pump, evaporator, feed filter tank and feed water heater. There is a very complete electric light installation fed from two dynamos, one of which is driven by a steam engine and the other by a paraffin engine. An electric driven refrigeration plant serves to maintain the required temperature conditions in a cold chamber of 240 cub. ft. capacity and to make 2 cwts. of ice every 24 hours. Two boilers of the latest Yarrow type are installed and are equipped for oil burning. The auxiliaries in the boiler room include a forced draught fan, main and auxiliary feed pumps and two complete oil fuel installations.

HILGER OPTICAL GAUGES.

DURING the war, Mr. F. Twyman, managing director of Messrs. Adam Hilger, Limited, designed a simple optical gauge for testing the cylindrical tubes of the eye-pieces of telescopes which are made in standard dimensions. The test is so easily applied that the gauge proved a real workshop instrument which, suitably modified, has been found very convenient for varied other tests. The main parts of the instrument, the principle of which will be understood from the diagrams Figs. 1 to 3, annexed, are a square box containing the source of light S, a pointolite lamp; a rest for the gauge G to be tested, consisting of two parallel blackened cylindrical brass bars B, clamped horizontally in front of the lantern; a glass plate P to which two pairs of lenses L_1 and L_2 are fixed by means of balsam; and, several feet away from the lantern, a screen, on which an image of the gauge is projected. The plate P is blackened all over except at the parts on which the lenses are mounted; the bars B rest in V grooves.



When no gauge is in position, the screen shows a nearly round disc of light. When a gauge is put on the rods, the field appears slightly greyish because the central portion of the light is blocked out. When the gauge is of the correct dimensions in the plane which happens to be vertical, the field remains uniform (Fig. 1). When the gauge as placed is too small, the grey field is crossed by a diametrical white band (Fig. 2); when the gauge is too large, the band is black (Fig. 3). If we turn a gauge, which is elliptical instead of circular in section, while resting on the bars, the bands narrow or broaden and change from white into black or *vice versa*. A scale is marked on the screen; the width of the band is equal to the error (deviation from the normal diameter) multiplied by the magnification due to the projection. When the gauge surface is rough or merely covered with dust, the edges of the bands are not straight, but show the irregularities of the surface on a magnified scale.

The optics of the combination are more simple than they appear at first glance. The condenser C, which is in reality plano convex and fills the whole circular aperture of the lantern, transforms the rays of the lamp into a parallel beam. Each of the two pairs of lenses L_1 and L_2 has its focus within less than an inch from the plate P, and when there is no gauge on the rods, two bright circular fields appear on the screen, overlapping more and more as we recede from the lantern. The parts are adjusted for the particular size of gauge to be tested, and the distance between the centres of the lenses L_1 and L_2, which are mounted vertically above one another on the plate P, is very slightly smaller—by about 0·01 in.—than the respective standard gauge. When the gauge is put into position, the grazing rays of Fig. 1 will intersect at the point A; if the gauge should be slightly in error, A would become visible as a fine bright or dark line; in that way the correct distance for the screen is fixed. With an undersize gauge the point A would appear as two points A_1 A_1 separated by a white gap (Fig. 2); with an oversize gauge, the two points A_2 A_2 would appear separated by a gap of extra blackness. Each of the two lenses L would alone produce a semicircle of greyish light, the lower semicircle corresponding to the upper lens, and *vice versa*. When the gauge is rough or dusty on top, the roughness shows as an inverted projection on the lower edge of a black band. In the black band any irregularity of more than the average diameter shows as a black projection outward, on the outside of the band, while any spot of insufficient thickness would appear as an inward indentation of the black edge. The opposite holds for a white band; all irregularities due to excrescences (of greater than the average thickness) show as grey projections inward, on the inside of the white band, making it narrower. We recognise that by covering up one of the lenses so that no light passes through. In the actual instrument the distance between projector and screen is 104 in.; the magnification is then 100-fold, and an error of 0·001 in. in the diameter of the gauge will be expressed on the screen by a black or white line, 0·1 in. inthickness.

It will be understood from what we have said that each standard gauge requires a special adjustment of the instrument. But the actual instrument described will take any gauge up to 2 in. in diameter. Within that range gauges of different sizes can be tested by adjusting the distance between the two lenses L. This can simply be done by gently heating the plate P until the balsam softens sufficiently to allow the lenses to be shifted, or by ordering a new lens plate.

A point of advantage of the optical gauge is that the test-piece does not require any accurate adjustment in position. The object to be examined is simply dropped into position by being placed on the two rods B or put into some other suitable holder. The same principle is also utilised for examining perforated plates as to the correctness of the spacings of the holes and for rapid testing of triangular prisms. In the latter case, three lenses L are required; they give a certain pattern with a correct prism' and the distor, tion of that pattern will indicate which parts of the prism tested are faulty. The instrument is indeed adaptable to a great variety of simple optical tests.

PERSONAL.—Messrs. Hans Renold, Limited, of Manchester, announce that their London address is now Bush House, Aldwych, W.C. 2, but that their telephone number will remain 8476 City, as previously.

THE LATE MR. BENJAMIN STOCKMAN.—We regret to announce the death of Mr. Benjamin Stockman, M.Inst. C.E., which occurred on Saturday, December 29, at his residence in Torrington Park, North Finchley. Mr. Stockman was, up to March, 1916, when he retired, assistant District Engineer in the main drainage works of the London County Council. He was born in 1851, and served articles with Messrs. Rouse and Stockman. After acquiring a varied experience in sea sluice works in Lincolnshire, in parliamentary railway work, as resident engineer to the East and West India Dock Company, on railway construction in Norfolk and in building dry docks in South Wales, he joined the staff of the Metropolitan Board of Works, now London County Council, and took part, under Sir Alexander Binnie, in the carrying out of the London sewage drainage.

CONSTANT PRESSURE INSULATION TESTER.

A NEW model of the well-known "Meg" insulation tester incorporating an important modification is being introduced by the manufacturers, Messrs. Evershed and Vignoles, Limited, of Acton-lane Works, Chiswick, W. 4. The "Meg" insulation tester which was introduced some fifteen months ago, and was described fully in our columns on October 13 of last year, is a simplified model of the Megger, which, in the twenty years or so of its existence has become almost the standard instrument for commercial insulation tests. The Meg was specifically designed to lend itself to repetition manufacture and to form a complete and self-contained insulation tester of minimum weight and external dimensions. The instrument comprises a 500-volt generator with driving gear and a moving coil ohmmeter unit and the total weight is only 6½ lb. In designing the instrument, the constant pressure clutch, which has, we believe, always been a feature of the Megger, was eliminated, and a direct geared drive was used. The result of this is that the Meg is a variable-pressure instrument which is, however, entirely satisfactory for testing circuits of small electrostatic capacity. It has been remarkably successful, but in order to extend its scope and utility it has been decided to incorporate a constant pressure clutch which, without sacrificing lightness and compactness, will result in an instrument having a considerably wider range of work.

When a testing voltage is applied between two insulated conductors, or an insulated conductor and earth, a current flows until the condenser formed by the system is charged to the applied potential. If there is no leakage the current ceases when the system is fully charged providing the applied voltage is maintained constant. If, however, the applied voltage varies, a varying capacity current will flow, the direction of flow depending on whether the voltage is increasing or decreasing. When measuring insulation resistance such capacity currents are superimposed on the leakage current and may make a steady reading difficult to obtain. For measuring the insulation resistance of house-wiring, machines and switch gear of which the capacities are small the capacity currents are so minute that they do not interfere with the reading of a variable-pressure instrument and the original form of Meg is quite satisfactory for the work. When, however, systems having a capacity approaching one microfarad have to be dealt with a steady reading is not easy to obtain with a varying pressure instrument, and for this reason the constant voltage feature has been introduced into the Meg.

The capacity of Messrs. Henley's lead-covered house wiring is 0·4 microfarad per mile, so that with large buildings wired with the material there is a possibility that the point will be approached at which the variable pressure instrument tends to become difficult to use. The constant pressure feature in the new model of the Meg is obtained by a slipping clutch which is introduced between the driving gear and the generator. One of the clutch members consists of a plate carrying spring-controlled levers and pressure pads which are so arranged that when the armature speed reaches a predetermined limit, the pads separate from the other driving element under centrifugal action. The arrangement prevents the armature being driven at a higher speed than that necessary to generate 500 volts, and the voltage may easily be held at that figure since all that it is necessary to do is to turn the driving handle at or above a fixed minimum speed. The constant pressure arrangement has an incidental advantage in that it prevents a higher voltage than 500 being applied to the circuit under test. A variable pressure generator driven fast enough might result in an applied voltage two, or even three, times the normal. In some cases this might be quite undesirable. The addition of the constant pressure clutch to the Meg has increased its weight to 7¼ lb., against the original 6½ lb.

INDUSTRIAL NOTES.

MESSRS. CAMMELL LAIRD AND CO., LTD., have issued a trade report for 1923 covering their different establishments. It states, with reference to their Sheffield and Penistone works that the entire stoppage of production in the Ruhr at the beginning of the year caused the diversion to this country of a considerable volume of orders for materials such as billets, rods and sheets, but at very low prices on the whole. December found steel makers in a substantially better position than could have been anticipated a few months ago. Reference is made to the order given the company at the end of 1922 of one of the two British battleships, and to the work this will bring to the company's steel works. The acquisition during the year of the Leeds Forge Company, Limited, and the Newlay Wheel Company, Limited, provides a satisfactory outlet for tyres, axles, springs and rolling-stock castings. The boilermakers' dispute dislocated the work of the shipyard and was responsible for serious unemployment. Messrs. Cammell's Nottingham Railway Carriage and Wagon Works were fairly employed, but work in most cases was not very remunerative. "All steel" bogie, high-sided and covered goods wagons have been built for a number of railways, and the development of a light steam rail coach has been an interesing feature of the activities of this establishment, which works in close co-operation with the other establishments now belonging to the company. Pullman cars have also been built. The Leeds Forge has been particularly occupied on long bogie carriage underframes, and an order has recently been obtained for 350 high-capacity wagons for the South African railways. In spite of the boilermakers' strike the output of corrugated furnaces by the Leeds Forge has considerably exceeded that for 1922, and during the past few months substantial orders have been received from the home railways for locomotive boiler plates. At the close of the year, the company was engaged in completing at the Leeds Forge an order for 920 pairs of wheels and axles for South African Railways.

The Transport and General Workers' Union have given formal notice to terminate the existing agreement which governs the dockers' wages and working conditions. It will be remembered that the agreement was set up under Lord Shaw's award. It originally fixed the minimum wage at 16*s.* per day in the larger ports and at 15*s.* in the smaller ones, since when it has been gradually reduced to 11*s.* and 10*s.* per day respectively, and a further reduction of 1*s.* in the summer led to strikes in various ports. The agreement is terminable by one month's notice as from the 1st inst. The men claim an increase of 2*s.* per day for time work, a corresponding increase for piece work and a guaranteed week. The National Amalgamated Stevedores, Lightermen and Dockers' Union are demanding an advance of 25 per cent.

As stated in our last issue, the National Union of Railwaymen have accepted the findings of the National Wages Board on wages and working conditions. The Railway Clerks' Association have since accepted them also as is evident by the following resolution which they passed: "That this Executive, having now considered in detail the recommendations contained in the report of the National Wages Board, particularly in so far as they affect our own members, approves the action of its representatives in signing the report, and resolves to recommend its acceptance by the members. Further, this committee instructs its Negotiating Sub-Committee to take all necessary action to pursue the matters dealt with in the summary of the report relating to night duty rates and conditions of the salaried staff, and allowances for junior clerks required to live away from home." The ballot papers of the Associated Society of Locomotive Engineers and Firemen were expected to be received last Tuesday; this has not been the case owing to delays no doubt caused by the holidays, and the executive have decided to extend the ballot period.

The special number for 1923 of the *Glasgow Herald*, covering shipbuilding and engineering, has an interesting article by Mr. Grant Barclay, president of the Shipbuilding Employers' Federation. Mr. Barclay states that common and united effort was never more needed in shipbuilding than now, for the events of the last three years have thrown into relief the seriousness of the industry's future position. For the last generation, warship construction has formed a considerable proportion of our annual shipbuilding output, but neither employers nor workmen can rely on the same proportion in the future. The building capacity of the industry was increased by about one-third to meet war requirements, and the *personnel* of the industry was likewise augmented. This additional capacity, added to the capacity engaged in pre-war times on warship work, and for which warship construction will not be available, means that we have not far short of double the facilities and the men to be maintained upon merchant shipbuilding as compared with pre-war. All the enterprise, the economic and scientific efficiency we can command will be needed to find, in the normal times of the future, markets that will occupy our available resources of plant and *personnel*. It should be remarked in connection with Mr. Barclay's above statements, that the shipyards proper are not alone affected by the changed conditions alluded to, but also the iron and steel industry of the country as a whole and many other subsidiary industries.

Friendly societies have come through a difficult year with a fair measure of success, says a correspondent in the same journal. Industrial depression, with under-employment and unemployment, with loss of wage-earning power, has in many instances made the payment of contributions by members to these thrift organisations a real sacrifice. It says much for the spirit of loyalty on the part of members that they have been prepared to make the necessary sacrifice to retain their membership intact. A similar spirit has in many instances been shown by members in more prosperous circumstances by allowing grants for distress funds, while gifts have also been made and the contributions of members who have been unemployed for months have been paid by their fellow-members. It is this side of the work of the friendly societies which distinguishes them from a mere business form of insurance. The actual insurance must be based upon sound business principles and actuarially framed tables of contributions and benefits, but beyond this there is the spirit of brotherhood and of help in times of misfortune which makes the friendly society so valuable a feature of the social life of the workers. The great controversy of the year has been with reference to the panel doctor's fee. There has been complete unanimity among those responsible for the administration of approved societies in opposing any payment to the panel doctor, beyond 7*s.* 3*d.* per annum for the medical attendance upon an insured person from the funds of the approved societies. This was the amount originally fixed. Labour leaders have conducted a most vigorous campaign in the matter, and the only thing that has been lacking has been any appreciable support from the millions of insured persons.

The agreement period for the third shift to be worked by the coal tippers and trimmers at the South Wales ports has been extended to the 19th inst. to allow time for further conferences on the subject. The conciliation committee, which is negotiating the situation, has adjourned until the 15th inst. It is to be hoped that the final outcome of the negotiations will be a decision to work the third shift.

The holiday period has also been responsible for delaying the drafting and sending out of the ballot papers to the miners on the National Wage Agreement. It is reported that the ballot papers will recommend the miners to vote for the termination of the agreement.

We read in *The Iron Age*, New York, that 7 of the 14 major industrial groups reporting to the Federal Employment Service, Washington, showed increases in employment during November. Net declines in 1,428 firms reporting was 0·5 per cent. of the total employed on October 31. In the iron and steel and allied trades, the decrease amounted to 2·85 per cent., in the railway repair shops the drop reached 2·35 per cent., and two factors—temporary curtailment of employment at most large railway centres during November and brief suspension of activities in iron, steel and their finished products—are held responsible by the survey for the decrease. A slight lull in the activities of machine shops and foundries has created a surplus of semi-skilled workers in these shops, but the demand for unskilled labour is still greater than the supply.

The same journal says that the work day in the steel industry of Japan is still as a rule the 12-hour day with alternating shifts. The workmen, however, are demanding an 8-hour day, but this has been granted so far only in sporadic cases. The Kawasaki Dockyard Company, Kobe, a few months ago instituted the 8-hour day. In other industries and in branches of the steel industry working only single shifts, the day turn is 9½ hours. In the steel industry Sunday is commonly a day of rest; in other industries work usually goes on over Sundays. In this case two days of rest are granted the workmen in each month, as a rule the first and fifteenth. The number of work days per year is therefore greater than 300 in spite of legal and religious holidays.

According to the monthly report dated December now issued by the Bank of London and South America, Limited, formerly the London and River Plate Bank, the Argentine press records with considerable satisfaction the steady increase in the number of immigrants who have landed during the past year. Over 180,000 is the balance in favour of the Republic and, more important still, the quality of these new arrivals is decidedly satisfactory. It is calculated that some 4,500 newcomers have arrived from Czecho-Slovakia in 1923, making that country fifth in order of entries, while other Central European lands have also sent important quotas; important not merely from a numerical standpoint, but also owing to the fact that almost invariably such immigrants are anxious to get on the land and are in the possession of sufficient capital to enable them to make a fair start. Italian labour is likewise arriving in Argentina very freely, and it, too, is more permanent in character than was much of the pre-war labour immigration. Thus, although unemployment is scarcely present, there is at the same time no shor age of labour, and as far as can be foretold, there is little danger of excessive demands on the part of the immigrants for the good and sufficient reason that the majority are not only workers, but have the sense to realize when they are well off.

BELT PULLEY GRINDING MACHINE.

CONSTRUCTED BY THE GRAHAM MANUFACTURING COMPANY, INC., PROVIDENCE, R.I., U.S.A.

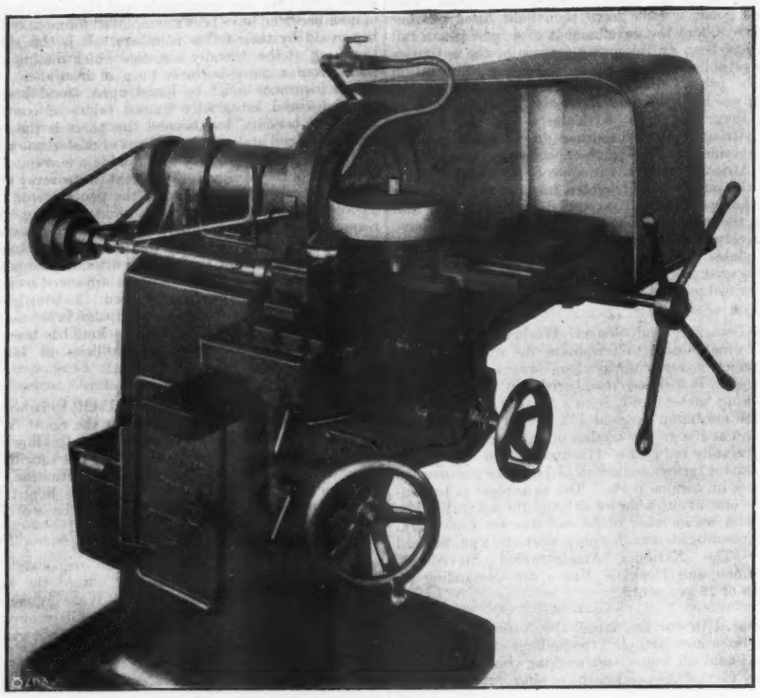
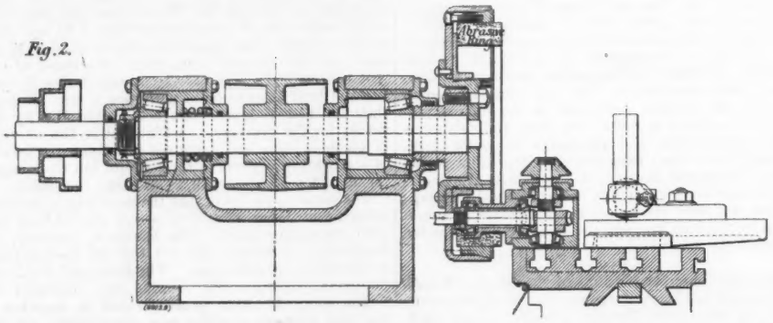
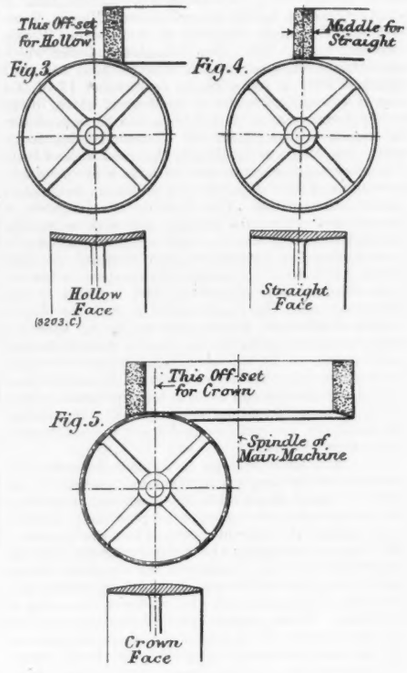
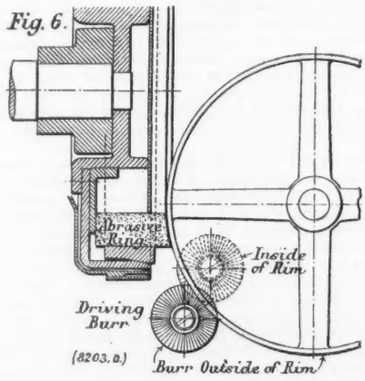


FIG. 1.







IN a recent issue, we gave a description of a surface-grinding machine made by the Graham Manufacturing Company, Inc., of 71, Willard Avenue, Providence, R.I., U.S.A.* In the accompanying illustration we show an adaptation of the smaller size of this machine to the special work of grinding the faces of belt pulleys. A general view of the machine is shown in Fig. 1, with a pulley in place in the act of being ground by the ring-grinding wheel. The machine is not intended for grinding conical or rimmed pulleys, but for finishing plain pulleys, which can be ground, either convex, flat or crowned as desired. The wheels can be ground from the rough after the hole and boss have been finished. The process will be clear from the view of the machine. The abrasive wheel is mounted on a chuck on a horizontal spindle running at about 1,500 r.p.m. The wheel has an outside diameter of 12 in., is 3 in. deep and has a thickness of rim of 1 in. It is held in the chuck by wedged segments, drawn by bolts towards the back of the chuck. The ring is backed, as shown in the section, Fig. 2, by an adjustable plate, by which it can be fed forward as wear takes place and the face is cut down. This can be done until a thickness of about only $\frac{1}{8}$-in. remains. The spindle runs in roller bearings, the back end one having a strong spring take-up arrangement, exerting a pressure of about 125 lb., in an outward direction which tends to keep the front bearing always on its seat. The spindle is belt-driven from a countershaft or by motor, as convenient.

The pulley to be ground is mounted on the vertical arbor, carried on the holder on the slide work-table. The arbor has to be selected to suit the hole bored through the boss, and has to be set vertically so as to bring the centre line of the pulley rim into line with the centre of the grinding wheel spindle. The type of surface ground is controlled by the relation of the vertical arbor to the grinding wheel rim. As will be clear from Figs. 3 to 5, with the arbor set in line with the rim, the face of the wheel is ground flat; if set outside the abrasive wheel diameter, the face of the pulley is ground hollow, while set inside, the face is crowned. The whole width of face is ground at one setting.

The pulleys are driven at a surface speed of from 50 to 250 ft. per minute, according to the condition of the casting, the hardness and grade of the abrasive, and the finish required. The driving mechanism is unique, and consists of a small conical burr which is driven through worm gear, as shown in Fig. 2, from a universal shaft. The latter is driven by a three-step pulley, belt-driven from a corresponding pulley on an extension of the main grinding spindle. The worm gear is mounted in roller bearings, and the cone pulley is fitted with a clutch, so that it can be started and stopped independently of the machine. By means of the cone pulleys a range of speed can be obtained. Commonly, no change of speed is needed for any diameter, as finishing is done merely with a lighter feed. The driving burr stands from 4 in. to 5 in. above the table and drives the pulley by contact with the lower edge of the rim. Its position is adjustable, but it should be placed as near as possible to the line of downward thrust of the grinding wheel. It does not matter which way the wheel is rotated, and the burr can be set inside or outside the rim, as convenient. When set inside, the arrangement is as shown in Fig. 6.

A considerable range of pulleys can be dealt with on the machine. The arbor-holder and splash-pans accommodate 24-in. pulleys, while the width of face can be anything up to about 6 in., but these are not absolute limits, and 30 in. diameter can be easily arranged for. The greatest field for the machine is the finishing of the large range of pulleys from 4 in. to 20 in. diam. Light pulleys of narrow width and small holes, as 16 in. by $2\frac{1}{2}$ in. by $\frac{3}{8}$ in., weighing 10 lb., can be finished as readily as standard designs. A suitable arbor is all that is necessary.

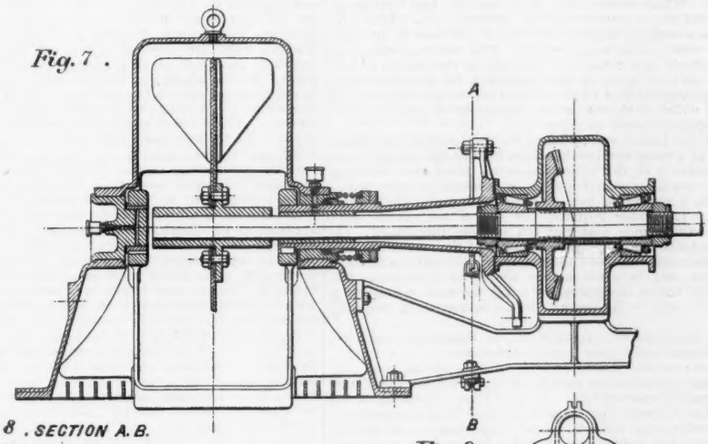
The abrasive ring does not need dressing in this work, but keeps its face correct as it wears down. Segments and intermittent circular surfaces can be ground by using an adaptor plate to take the drive from the burr. A great saving is effected over lathe work. The machine takes about 10 h.p. to drive it. It is fitted for wet grinding, having a Brown and Sharpe centrifugal pump without packing and below water level.

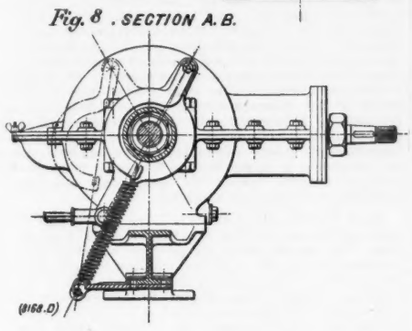
* Vol. cxvi., page 680.

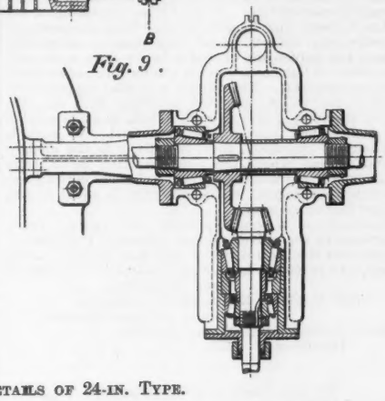
WATER TREATMENT.—The Chemical Engineering Group of the Society of Chemical Industry are arranging, with the support of the Institution of Mechanical Engineers, for a discussion on all phases of "The Treatment of Water for Industrial Purposes," which will be held on January 25, probably in the Institution Lecture Hall. The subject will be dealt with by the discussion of a number of separate papers. When all the arrangements in connection with the meeting are completed detailed announcements will be made.

HOTCHKISS HYDRAULIC PROPELLERS.

CONSTRUCTED BY THE HOTCHKISS HYDRAULIC PROPELLER COMPANY, LIMITED, LONDON.





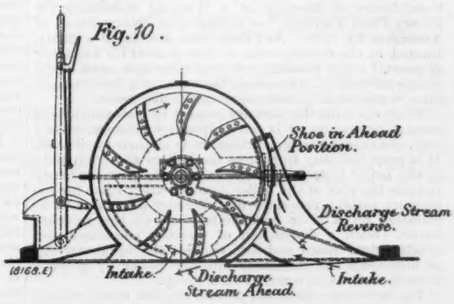


FIGS. 7 TO 10. DETAILS OF 24-IN. TYPE.

FOR the navigation of very shallow waterways the ordinary methods of ship propulsion have certain disadvantages which can only be overcome by the introduction of modifications of the usual equipment. In this sphere of service screw propellers have been installed in tunnels, stern wheels have been adopted, or the vane wheel system, in which there is only a partial immersion of the revolving blades, has provided a solution. Another method, that of hydraulic propulsion, was early introduced to obtain efficiency, but lack of knowledge of the true nature of many of the factors involved has been responsible for the somewhat slow development of the process. With the acquisition of greater knowledge, improvements have been effected, and to-day the system has reached the state hoped for by the original workers but never previously attained. The process consists simply in using one or more engine-propelled pumps within the vessel, which draw water from the river and discharge it in jets in such directions as are necessary to give the required motion, ahead or astern. One worker who has contributed greatly to the development of this system is Mr. D. V. Hotchkiss, of the Hotchkiss Hydraulic Propeller Company Limited, 26, Martin Lane, Cannon Street, London, and a number of illustrations accompanying this article show the designs and lay-out arrangements he has devised. The illustrations, Figs. 1 to 6, on page 16 show a hydraulically propelled tug, the lay-out of the machinery for it, and a view of the pumps. In the other illustrations, Figs. 7 to 10 above, the drawings of the construction of a smaller size of pump are given.

The tug Hotchkiss, which is shown on the Thames in Figs. 1 and 2, is constructed of steel, is practically of box form, and has the following dimensions :—length 40 ft.; beam, 8 ft.; and depth, 2 ft. 6 in. When light the draught is only 11 in., which is increased to 17 in. when 4 tons of cargo, its full carrying capacity, are carried. This tug is capable of towing four monkey barges, each laden with 25 tons of cargo at a speed of 3½ m.p.h. The speed when fully loaded, but not towing, is 7 knots. The engine of the installation is a two-cylinder Bolinder motor of 30 b.h.p. From the lay-out drawings, Figs. 3 to 5, the engine is seen to be centrally situated, while the pumps are fixed in positions at the sides of the boat. The drive from the engine is taken through a clutch, and consequently the engine may be started free, either preliminary to the actual propulsion of the tug or for testing. The pumps have a number of vanes or impellers, and the positions at which the water is taken in and discharged can be changed at will, to suit ahead or reverse working, by the movement of a shoe, in the form of a segment of a drum. This shoe (Fig.10) can be turned through an angle of 70 deg., and in that way the water may be deflected, to pass out at the base of the pumps either towards the bow or the stern. The standard astern speed is 0·6 of the ahead value, but this may be increased, by changes in the design, to give as high a ratio as 0·75. From full speed the vessel may be brought to rest in about 6 sec. The details of the construction adopted for the pump and its accessory gear are shown in the drawings of the smaller unit, Figs. 7 to 10.

The impellers, Figs. 7 and 10, have curved faces, and are made in halves and erected on the central disc, which has a circular hole at its centre to permit of its accommodation on the hub, against a flange to which it is bolted. The shoe is suspended from the bearings by curved side-arms, and in Fig. 10 is shown in position for ahead running. The intake for the water is arranged at each side of the pump, and grids are provided to prevent the entry of any solid matter which might injure the rotating parts. The outlets are arranged in line with the pump casing. When the shoe is pulled round to close the outlet for ahead running, it opens the discharge channel for reverse operation. In the middle position the operation of the pump would be such that no movement of the boat could take place. Other locations of the shoe permit running at greater or less speed, ahead or reverse. The mechanism for use in effecting the requisite change of position of the shoe is shown in Figs. 7 and 8. A sleeve on which the shoe is suspended on the bearing may be turned by motion from a hand lever. The tube has a flange at its end on which a small arm is provided through which the motion is communicated to it. The location of this and the manner in which the retaining spring is fitted are shown in Fig. 8. In this installation, where the impeller has a diameter of 24 in., the control is somewhat different from that of the 30-in. diameter pumps of the tug Hotchkiss. In that case, as will be seen from Fig. 6, the levers are mounted beside the driving gear at the centre, and their motion is carried by lay shafts to levers fixed to the short sleeves on which the shoes are mounted. In both cases the drive from the engine is by means of bevel gearing, and the details of the arrangement of this part of the mechanism are clearly indicated in the section in Fig. 9.



It will be understood that the engine may be kept running under full load, while the speed of the boat may be varied in any way that is desired by the operation of the control handles and so changing the shoe positions. During the passage of the water through the propeller acceleration of the water takes place, as the intakes are together larger in area than the discharge outlet. The fundamental difference between these propeller pumps and the pumps used for ordinary purposes is that the water is not brought to a state of rest by passing into the system at the centre. The water for the pump used in the Hotchkiss system passes into the spaces between the impellers at a place somewhere between the centre and the circumference, where the rotational speed is approximately equal to the relative velocity of the intake flow. A very high velocity of discharge relative to the rate of movement of the ship is not wanted. Theoretically, it should be as low as possible, and the cross sectional area of the discharge stream is kept as large as is obtainable, consistent with the attainment of the acceleration necessary to produce the thrust. It will also be noted that there are no pipes, turns or sharp bends, and no conversion of pressure energy into velocity energy or the reverse, which would all cause losses. The incidental advantages attained are reduction of vibration and the entire absence of any external parts of the propulsion mechanism. It is also claimed that, as the pumps may be so equipped that they can be made to draw water from the inside of the vessel in time of accident, the system has advantages on the score of safety at sea, which may commend its use for some types of larger vessels.

MINERALS IN RHODESIA.—A circular to the shareholders of the Rhodesian Congo Border Concession, Limited, referred to in *The South African Mining and Engineering Journal*, states that in the eastern portion of the concession a number of copper prospects have been reported. Very large deposits of manganese have also been traced, but these can only become of value when the railway system of that part of the country where they occur is further developed. Large deposits of graphite have been discovered in the proximity of the railway. In one of the streams in the eastern portion of the concession the presence of gold has been reported.

ELECTRIC TRACTION MATERIAL.—An important arrangement in connection with the manufacture of electric traction material has been come to by the General Electric Company, Limited, of Magnet House, Kingsway, W.C. 2, and Witton, Birmingham. The company has established a traction department and is in a position to manufacture at its Witton works traction plant and equipment of all kinds for both direct and alternating current systems. In order to add to the technical experience at its command the company has come to an agreement with the Oerlikon Company to utilise the designs which it has available and which represent thirty years of electric traction experience.

THE WELLAND SHIP CANAL.—According to *The Canadian Engineer*, tenders have been invited for the construction of Section 8 of the Welland Ship Canal. This section, it is understood, will contain some particularly heavy excavation, as a considerable part of the canal will have to be cut through rock, and it also includes the construction of a long breakwater in Lake Erie. A change has been made in this section, the new line is straighter and will involve a new lock and considerable work in the town of Port Colborne. About 2,500,000 yards of rock and 1,000,000 yards of earth will have to be removed. The new lock will have a useful length of 900 ft., width 80 ft. and depth of water 30 ft. There will be six bridges in the section, including three movable ones, probably of the bascule type. The breakwater in Lake Erie will be 2,000 ft. long and will be built of spoil from the canal excavation. A good deal of dredging will have to be done at the lake end. When this contract has been let there will still be sections 6 and 7 to finish, the work on these consisting of enlarging the present canal and constructing some bridges.

MERCURY AS A WORKING SUBSTANCE FOR BINARY FLUID TURBINES.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with interest the remarks made in the discussion of Mr. W. J. Kearton's excellent paper "The Possibilities of Mercury as a Working Substance for Binary Fluid Turbines," as published in ENGINEERING of November 23, 1923. As I have been associated with Mr. Emmet in the development of this process for a number of years, I might possibly put some light upon some of the points referred to. I cannot, however, in a letter undertake to discuss all points raised in the discussion.

When applying the mercury process to a steam-turbine generating station, it is not proposed to change, in any way, the existing steam-turbine units or their auxiliaries. It is proposed only to change the boilers and equipment in the boiler house. In some cases it may be necessary to raise the roof of the boiler house to allow room for the mercury-turbine generator and mercury condenser to be installed on a floor immediately above the mercury boiler. Such a disposition of mercury condenser economises floor space and also enables the liquid mercury to flow from the condenser into the boiler by gravity, thus eliminating a mercury feed pump.

The mercury equipment can be applied to any steam-generating plant whether it operates with low or high-pressure steam. As an example we will take a steam-turbine generating plant using 200 lb. steam pressure, having the highest standards of efficiency in turbine and auxiliaries. In this plant we could install mercury apparatus in the boiler house and use 35 lb. gauge pressure of mercury vapour. Judging by recent results, we would expect, in such a plant, to generate 52 per cent. more output in electricity per pound of fuel. And, if in such a plant the boiler room is re-equipped with furnaces and mercury apparatus arranged to burn 18 per cent. more fuel, the station capacity with the same steam turbines, condensers, auxiliaries, water circulation, &c., would be increased about 80 per cent. As compared with higher steam pressures, such as are now being developed, the percentage of gain would naturally be less.

We believe that this large increase in output and greatly improved fuel economy can be obtained in this way cheaper than by making the usual extensions of equipment and buildings. Aside from giving the above results we believe that this apparatus will be reliable and the maintenance very low. Provided the mercury boiler is designed to give the desired output, with the most intense firing it should operate without deterioration, as mercury does not form scale on the inner surfaces of the boiler as scale is formed in water boilers. The tubes of the steam boiler or mercury condenser will, of course, be immune from burning as the temperatures are too low.

The turbine blades at present installed at Hartford are made of nickel steel, the same as used for steam turbines. There are also in this wheel a few blades made of tool steel, but experience to date indicates that the nickel blading will be entirely satisfactory for a single wheel turbine. All other parts of this mercury equipment are made of the usual grades of commercial steel.

The installation at Hartford occupies a floor space no greater than needed for a steam boiler having 6,000 square feet of heating surface. The equipment is designed to develop 1,800 kw. from the mercury turbine generator and the condensing mercury at this load will generate at least 28,000 lb. of water steam per hour, which is superheated to about 100 deg. F. The equipment has not operated yet at this load, as it has been thought expedient to get experience with continued operation at reduced loads, and then gradually increase the load. We have operated the plant generating 1,500 kw. from the mercury turbine and 27,000 lb. of steam per hour.

The Hartford equipment holds about 32,000 lb. of mercury. Since this apparatus was designed, experience on experimental equipment indicates that considerable reduction can be made in the amount of mercury needed for future equipments. This reduction is made by reducing the size of mercury spaces in the mercury boiler and mercury economizer.

Although the Hartford apparatus is designed for 50 lb. abs. pressure, and the vapour superheated 40 deg. F. (total temperature 852 deg. F.), there are at present no indications that this is the maximum pressure possible. The mercury, when condensing, forms steam at 200 lb. gauge pressure with a temperature drop across the condenser tubes of 20 deg. F. This water steam at 200 lb. gauge pressure is superheated to about 100 deg. F. and delivered to the station steam line and expanded in the steam turbines.

Yours very truly,
BEVIS P. COULSON, JUNR.

December 12, 1923.

"POWDERED COAL FOR STEAM RAISING."

TO THE EDITOR OF ENGINEERING.

SIR,—Your article, "Powdered Coal for Steam Raising," in the December 14 issue of ENGINEERING, will undoubtedly be appreciated by technical men as throwing further light on a subject which is becoming of increasing interest and upon which I claim indulgence to make a few remarks.

The paper recently given by Mr. D. Brownlie before the Institution of Electrical Engineers on this same subject contains a mass of information which must be of primary interest to all power plant engineers. Pulverised fuel application to both steam generation and metallurgical furnace practice is so rapidly becoming a consideration of first importance that the more data which can be published in this connection, the better will it be for all concerned. Practically all definite working figures which are available from plants operating pulverised fuel installations come from central systems. Is it not time, therefore, that some authentic data from the unit systems be published, giving the same scope for analysis as Mr. Brownlie's paper offers for the central pulverising installation? I think that most engineers recognise and admit the benefits and advantages of pulverised coal. What worries them is to find the best system of application, a system which is practical, one which will operate without trouble and which will best fit in with their own special requirements. Practical experience of pulverised coal firing is so limited in this country that engineers are more or less dependent for guidance upon the pulverised fuel firms, a situation no man enjoys and from which it should be the endeavour of publicity and the technical press to relieve him.

I think that it can be taken for granted that pulverised coal as a firing medium has come to stay, and suggest that comparison of the various systems under the following main headings would answer as a useful primary guide to the prospective user of pulverised coal: (1) Capital cost; (2) power required per ton of coal pulverised; (3) maintenance cost per ton of coal pulverised; (4) attendance cost; (5) the guarantee of the manufacturer; (6) the normal life of the pulveriser; (7) will the fineness of the coal be continuously the same throughout the normal life of the pulveriser? (8) the cost of delivering the raw coal to the dryer or unit, which ever the case may be.

A complete investigation of the foregoing would undoubtedly yield some useful conclusions.

Your article makes special mention of the unit pulverisers installed on two Spearing boilers at the Peterborough power station. It would be interesting to all readers to learn how long these have been in operation, and with what success. I ask this question specifically because the pulverising of coal is heavy duty work, and no machine of light construction can for long successfully stand up against it. The scheme of employing one small machine per boiler, mounted complete with its own driving medium, is very attractive but, as experience in the States has proved, not practical. As regards simplicity of operation, there is nothing in the modern central system which the most exacting could term complicated; the working and control of the entire plant is simple to a degree, whilst reliability is equal to any modern fuel oil system.

Speaking for a company with over twenty years' experience in the pulverised coal industry, I venture to predict that the central system will stay and win in this country the success it has already achieved in the States.

Yours faithfully,
THE HOLBECK ENGINEERING COMPANY,
(W. BOON, Manager Director).

34-35, Norfolk-street, Strand, London,
December 27, 1923.

TO THE EDITOR OF ENGINEERING.

SIR,—I must crave permission to take up a little more space in order to reply to the letter of Mr. C. E. Atkinson in your issue of the 28th. Mr. Atkinson states:—

"He (Mr. Brownlie) gives a figure of 850,000 tons to 1,000,000 tons per annum used by one system of central pulverisation, which system we are led to believe is the most important in the United States. It is difficult to know how this figure is arrived at . . ."

Mr. Atkinson will find the necessary information on page 4, of my paper, first column, lines 22 to 31, from the top of the page, as follows: "About the middle of this year (1923) the number of large boiler plants in America on the 'Lopulco' system was nine, comprising 43 boilers with a total heating surface of approximately 360,000 sq. ft. Probably about 300,000 sq. ft. of this is in operation at any one time which at the very moderate figure (low capacity plant) of 0·75 lb. coal burnt per square feet of heating surface per hour (6·50 lb. water evaporated) corresponds to, say, 120·5 tons per hour, or something like 850,000 tons to 1,000,000 tons per annum."

Mr. Atkinson then goes on to state, "If we take one system of unit pulverisers, the turbo-pulveriser, and calculator, the normal output of those ordered, we get an annual output of over 1,800,000 tons calculated on a working year of 300 days."

This, however, is a confusion of the point at issue. I am concerned solely with steam generation and not all kinds of furnaces indiscriminately, and my figures of 850,000 tons to 1,000,000 tons now in operation and 2,600,000 tons on order refer only to steam boilers. About 30,000,000 tons of pulverised coal per annum is being burnt for all purposes, and in a very large number of cases the so-called unit pulveriser seems to be in use mainly because there is no means of determining the exact efficiency of the furnace. In my paper I have described the "Lopulco" system and given the detailed performance figures of an entirely unbiassed engineer, Mr. John Anderson, of Lakeside, Milwaukee, because no other figures so far as I know are available of equal accuracy, length of operation, or size of plant.

Perhaps Mr. Atkinson will give us the number and capacity of turbo-pulverisers, at work and on order, for steam boilers, the size of the boilers, and the results of tests, not for a few hours, but for a few months continuous running.

Yours faithfully,
DAVID BROWNLIE.

46, Grange-road, Ealing, London, W. 5,
December 31, 1923.

CYCLES FOR JAPAN.—The Acting Commercial Secretary at Tokio reports that, owing to the destruction by the recent earthquake and subsequent fire of large numbers of bicycles and bicycle factories, there is a demand for material and parts. Further information is in the possession of the Department of Overseas Trade.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The New Year has opened with improved prospects for virtually every section of local industry. A steady diminution in unemployment accompanied by a comparable rise in output has marked the last four or five months' trading, and to-day manufacturers are quietly hopeful not only of improved business from the tonnage standpoint but of securing contracts that will yield a more reasonable margin of profit. In the armament section trade organisers point to the expected early advent of contracts on Government account in connection with the decision to build 17 light cruisers. The work to be given out should form a useful supplement to that now under execution respecting the building of the two large battle cruisers. Taking a wider outlook, engineering masters point to the receipt of an increased volume of work from British railways, and to the existence both at home and abroad of far-reaching projects relating to transport development with particular application to electrification schemes. The progress of negotiations offers reasonable promise that this and allied districts will succeed in attracting Colonial orders for the supply of a heavy tonnage of materials for bridge building. Wagon and locomotive works have resumed with improved order books. With many firms the average pre-war tonnage has been passed, and there is definite prospect of the putting into commission of comparatively new plant which for several months has stood inactive. In lighter machinery and steel-implement branches the outlook also gives increased cause for hope. British and Colonial engineers are taking a larger supply of practically all classes of tools. Several nice orders have just been booked for files, saws, and twist drills. A satisfactory feature is the indication of an early revival on Continental account. Steel-makers in this district are re-opening agencies in Poland, Czecho Slovakia, Italy and other Continental markets, and experience no difficulty in securing distributors for their goods. This definitely points to the existence on the part of Continental distributors of a knowledge of the possibilities of trade expansion in the countries concerned. Special steel branches are slowly improving. The building trades are absorbing a larger output of tools, castings and fittings. Colliery orders for gear and coal-cutting machinery are also in the ascendant.

South Yorkshire Coal Trade.—There is likelihood of an early advance in the price of both domestic and industrial fuel. For several weeks the position has steadily been hardening in favour of sellers, supplies being somewhat scarce owing to wagon shortage and dock delays. Hard steams represent a firm market, with home sales rising and export demands maintained at a high level. More bunkering coal is leaving the collieries. Best quality slacks are steadily being absorbed, while recent weakness in cobbles and nuts has largely disappeared. The general demand for house coal is on a much more robust scale. Gas cokes are in active demand for shipment. Quotations:—Best handpicked branch, 33*s.* to 34*s.*; Barnsley best Silkstone, 27*s.* 6*d.* to 29*s.*; Derbyshire best brights, 27*s.* to 29*s.*; Derbyshire best house coal, 23*s.* to 24*s.*; Derbyshire best large nuts, 22*s.* to 23*s.* 6*d.*; Derbyshire best small nuts, 17*s.* 6*d.* to 19*s.* 6*d.*; Yorkshire hards, 22*s.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* to 22*s.* 6*d.*; rough, 12*s.* 6*d.* to 13*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 5*s.* to 8*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Holidays are still interfering with business, but a steady, firm feeling prevails, and early resumption of activity is confidently looked for. Output of Cleveland pig-iron is being further increased by the rekindling of another idle furnace. Home requirements are on quite a good scale, and are expected to steadily increase, but demand for abroad is on a very limited scale, and there appears to be little likelihood of any early material growth of export business. No. 1 Cleveland pig-iron is 106*s.*; No. 3 g.m.b., 100*s.*; No. 4 foundry, 97*s.* 6*d.*; and No. 4 forge, 96*s.* 6*d.*—all f.o.t. makers' works, and f.o.b. Tees.

Hematite.—In the East Coast hematite branch also Continental inquiries are few and small, but transactions for home consumption are fairly large and are expanding. Some heavy forward contracts have been made and output promises to be fully absorbed. Nos. 1, 2 and 3 are fully 102*s.* 6*d.*, and many makers ask 103*s.* 6*d.*

Foreign Ore.—Values of foreign ore tend upward, sellers taking a firmer stand and regarding prospects as distinctly brighter. Quotations are based on 25*s.* c.i.f. Tees for best rubio.

Coke.—Supply of blast-furnace coke is ample. Good average qualities are round about 37*s.* delivered to users in this district, but consumers consider the price still too high.

Manufactured Iron and Steel.—Producers of practically all descriptions of manufactured iron and steel are now well placed as regards orders, and steady expansion of business seems probable. Increasing activity at shipyards promises freer distribution of specifications for shipbuilding requisites, and further contracts for railway material are expected to be secured. Common iron bars are 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 5*s.*; steel angles and joists, 10*l.*; heavy steel rails, 9*l.* 10*s.*; fish plates, 13*l.*; and galvanised corrugated sheets, 18*l.* 15*s.*

Shipments of Iron and Steel.—December shipments of

iron and steel from the Tees reached 8,684 tons, of which 23,948 tons were pig-iron, 4,047 tons manufactured iron, and 58,845 tons steel. Among the chief customers for pig-iron were Germany, 2,085 tons; Wales, 1,900 tons; Belgium, 1,899 tons; Scotland, 1,810 tons; Danzig, 1,700 tons; Italy, 1,560 tons; Japan, 1,311 tons; Finland, 1,250 tons; and Denmark, 1,207 tons. Natal was the principal buyer of manufactured iron taking 1,524 tons. Heaviest recipients of steel were India, 12,650 tons; New Zealand, 8,974 tons; Japan, 6,225 tons; New South Wales, 3,962 tons; Cape of Good Hope, 3,801 tons; Natal, 2,121 tons; Victoria, 1,394 tons; Canada, 1,233 tons; Portuguese East Africa, 1,067 tons; and Denmark, 1,042 tons.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The question of third shift working by the coal trimmers and tippers at the South Wales docks has been the subject of consideration by the Court of Inquiry appointed by the Minister of Labour during the past week. Failing an agreement night work was to have come to an end on Saturday, but the court acting as mediator between the parties concerned has submitted recommendations, which if adopted, will mean the continuation of the third shift for another fortnight, during which time it is hoped negotiations will be conducted which will lead to a permanent settlement. The court state it has carefully examined the considerations submitted to it by the chosen representatives of the employers and the men, and is of the opinion that in the interest of all concerned in the trade of South Wales, the partial third shift should be continued, and that the committee established at each port under the agreement of May 12 last, should forthwith consider any suggestions from either side for the furtherance of the work and promotion of efficiency, including the question of the number of appliances to be worked on the partial third shift, and that the committee should thereafter meet regularly on a fixed date, say, the first Monday in every month. The court was, however, impressed by the fact that the financial position of the tippers had been adversely affected by the introduction of the third shift, and the court considered that a conference should forthwith take place between the Great Western Railway Company and the tippers' representatives with a view to the adjustment of this question. The court was not unanimous that the same case had been made out by the trimmers and recommended that any claim they may desire to put forward should be submitted to the South Wales Area Board and if necessary to the National Trimming Board. The court accordingly suggested that the agreement to continue the partial third shift without prejudice to any question involved should be extended to Saturday, January 19, in order that the conferences respecting the tippers and trimmers respectively may be held with the view of effecting a settlement in the meantime. The court then adjourned until January 15, pending the result of the conferences. Subsequently the tippers and trimmers' representatives met and decided to meet their respective employers with a view to settling the financial details. The tippers meet the Great Western Railway Company, and a meeting of the South Wales Area Board has been convened to consider the position of the trimmers. Mass meetings of the men are also to be held to consider the recommendations of the court.

Iron and Steel.—Exports of iron and steel goods last week owing to the intervention of the holidays amounted to only 4,786 tons of which 301 tons of tin plates and terne plates were shipped from Newport, 2,356 tons of black plates and sheets, 1,850 tons of galvanised sheets and 279 tons of other iron and steel goods.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—In the Scottish steel trade there was a little activity before closing down for the holidays, but nothing like what we have experienced in some past years. At this time last year we were anticipating a good run in all, or nearly all, classes of material, but 1923 must now be written down as a somewhat disappointing year in which hopes were raised and then badly shaken. Certainly tonnages are up in some departments, but the heavy oncosts have taken away much of the gilt. Perhaps the most disastrous thing which has happened to the steel trade for some years was the lock-out of boilermakers, as the outlet for material was tremendously reduced during the six months these workers were idle, and particularly was this the case in ship plates, &c. With the settlement a small demand for plates and sections came along, but as shipbuilders had so few orders booked it was only of a very limited nature. It has gradually been improving, but before ship plates, &c., will be required in any volume a very considerable amount of new tonnage will need to be placed by shipowners. Prices over the year have not varied greatly, but the close of the year found them on a higher level than at the opening. The home quotations at the beginning and end of 1923 were as follow:—

	January, 1923. Per Ton.	December, 1923. Per Ton.
	£ s.	£ s.
Boiler plates	12 0	13 10
Ship plates	9 0	10 5
Angles	9 0	10 0
Joists	9 0	10 0

With the exception of boiler plates, which marked no fall in price over the year, the other items mentioned each firmed up in the spring months, eased off in the autumn and recovered again in the month of December. The export prices were generally easier by about 5*s.*, 10*s.*, or 15*s.* per ton.

Black Sheet Trade.—The makers of black sheets have done tolerably well over the year from an output point at any rate, although trade has been somewhat patchy at times. The demand for the lighter gauges has perhaps been best both on home and export account, but occasionally there were short runs for the heavier gauges. In the latter some improvement was noted towards the close of the year, when there was a little more doing for the home market. Galvanised sheets were fairly good at some periods of the year and the output has been not so bad overall. The prices during 1923 showed little fluctuations. Black sheets, ¼ in. basis, which were called 11*l.* 10*s.* per ton in January, increased 10*s.* per ton in both March and April, but although showing a slightly easier tone in the autumn maintained firmness towards the close of the year, when 12*l.* 10*s.* per ton was quoted. The future is being looked forward to with hope.

Malleable Iron Trade.—The West of Scotland malleable iron trade has just passed through rather a mixed year, but at the close business was considerably better than during a good portion of it, and indications are not wanting that there are better times ahead. Last year opened well, but a tapering off took place before long, and not only did short time become general, but later on a number of works were forced to close down completely owing to lack of demand. The export side of the trade has been only moderate, but inquiries now in circulation seem to point to a fairly large tonnage being wanted for the overseas markets in the near future. Prices varied slightly over the year, and after being firm at the beginning, fell away about the month of April, and continued weak until about the end of the year, when the tone became firmer.

Scottish Pig-Iron Trade.—The past year has been a far from satisfactory one in the Scottish pig-iron industry and the continued dull trade has had a very depressing effect. The number of furnaces in blast averaged but 27 (on ordinary iron), and the output from them, coupled with the stocks on hand, was more than equal to the demand. Prices rose and fell during the year according to circumstances. In January, No. 3 foundry iron was called 95*s.* per ton, on trucks at makers' yards, but by the end of that month 98*s.* 6*d.* per ton was the quotation. Then the Ruhr business came along and early in February, 102*s.* 6*d.* per ton was touched, and a week or two later the price was called 107*s.* 6*d.* per ton, and then it advanced to 112*s.* 6*d.* per ton, while in March the figure was 118*s.* 6*d.* per ton. After 120*s.* per ton had been reached a dullness came along in April when the value dropped back to 117*s.* 6*d.* per ton, followed by 115*s.* per ton in May, 111*s.* 6*d.* per ton in June, 107*s.* 6*d.* per ton in July, and 100*s.* per ton in August. In the month of September when the price was round about 99*s.* per ton buyers began to take a little more interest, and in the following month 102*s.* per ton was the quotation; but when the lock-out of the boilermakers came to an end in November the price became firmer at 5*l.* 5*s.* per ton and continued to get better and closed for the year at 5*l.* 6*s.* 3*d.* per ton, an increase of 11*s.* 3*d.* per ton from this date last year. Producers of hematite iron have had rather a lean year owing mainly to the quietness in the steel industry.

Scottish Shipbuilding.—The story of the Scottish shipbuilding industry for the year 1923 can be briefly summed up in the words "exceedingly disappointing." At no time was there the least sign of activity, and depression was general throughout almost the whole year. The demand for new tonnage was of the most meagre description and consisted mainly of special vessels for specific purposes. Cargo-carrying vessels were in very poor request owing to the quietness of general trade, and only urgent orders were given out. But perhaps the most important happening during the year was the disastrous dispute with the boilermakers over the overtime and night-shift agreement. It lasted for fully half the year and any chance of a revival in demand for new tonnage faded away. When a settlement was reached and work restarted in November hopes were raised that new contracts would be given out by shipowners and a few have certainly been secured, but a score or two more are still required quickly if activity in the yards is to be general. All the Scottish districts are down when compared with the previous year, with the exception of the Dee and Moray Firth, which is 541 tons up from 1922. The following are the figures for the different districts for the year 1923:—

	Vessels.	Tons.	I.H.P.
The Clyde	122	175,528	166,956
The Forth	24	13,426	1,750
The Tay	6	23,258	9,850
The Dee and Moray Firth	10	4,348	3,950
Total for 1923 ...	162	216,560	182,506
Total for 1922 ...	190	446,997	366,711
Difference ...	28	230,437	184,205

The total output from our chief shipbuilding district, the Clyde, compares very badly with recent years, being 21 vessels and 212,953 tons below 1922, which was an admittedly poor year, and 248 vessels and 581,448 tons less than the record year of 1913. It is thirty-seven years since the Clyde output was smaller than during the twelve months of 1923, and in that year—1886—the figures were 166 vessels of 172,440 tons. The outlook for this year is certainly a bit better, and if only trade disputes can be avoided the prospect of a better return a year hence is very likely. General business has gradually been improving during the past two or three months, and all are hopeful that this year will mark a considerable advance on the one just gone.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, January 4, at 7 p.m. Informal Meeting. Subject for discussion: "Mechanical Methods of Boiler Firing," to be introduced by Mr. H. P. Gaze. Friday, January 11, at 7 p.m. Informal meeting. Demonstration of Cinematograph Films on the Construction of a Aero Engine and other subjects.

THE INSTITUTION OF THE RUBBER INDUSTRY.—Monday, January 7, at 8 p.m., in the Kelvin Room of the Engineers' Club, Coventry-street, Piccadilly, W. Paper by Dr. Sam S. Pickles, on "Consistency of Rubber and Rubber Compounds."

THE BRADFORD ENGINEERING SOCIETY.—Monday, January 7, at 7.30 p.m., Lecture in the Hall of the Bradford Technical College. Mr. J. Shaw (of Manchester), on "Modern Developments in Electrical Driving of Textile Mills," illustrated by lantern slides and the cinematograph.

THE INSTITUTION OF CIVIL ENGINEERS, NEWCASTLE-UPON-TYNE ASSOCIATION.—Tuesday, January 8, at 7.30 p.m., in the Lecture Theatre, Neville Hall, Newcastle-on-Tyne. First Vernon-Harcourt Lecture on "River Training and Maintenance Work," by Mr. R. F. Hindmarsh, M.Inst.C.E.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, January 8, at 6 p.m. Paper to be submitted for discussion: "An Account of an Examination of the Menai Suspension Bridge," by Mr. Henry Tudsbery Tudsbery, M.C., M.Inst.C.E., and Mr. Alec. Robert Gibbs, Assoc.M.Inst.C.E. Students' Meeting, Wednesday, January 9, at 6 p.m., Lecture on "The Work of a Constructional Engineer's Office," by Mr. John Mitchell Moncrieff, C.B.E., M.Inst.C.E. Students' Visit to the National Physical Laboratory, Saturday afternoon, January 5.

THE INSTITUTE OF METALS: NORTH-EAST COAST LOCAL SECTION.—Tuesday, January 8, at 7.30 p.m., in the Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-on-Tyne. Paper on "The Action of Molten Brass on Nickel Steel," by Mr. H. M. Duncan, B.Sc.

THE INSTITUTE OF METALS: BIRMINGHAM LOCAL SECTION.—Tuesday, January 8, at 7 p.m., in the Chamber of Commerce, New-street. Paper on "Nickel Brasses," by Mr. O. Smalley.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, January 8, 6.30 p.m.—"Modern Refrigerating Machines," by Mr. R. G. Reid (Member).

INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, January 8, at the Royal Society of Arts, John Street, Adelphi, the following papers will be read—"The Crude Oil of Sarawak." By James Kewley, M.A., F.I.C., F.C.S., and "The Crude Oil of Maidan-i-Naftun." By A. E. Dunstan, D.Sc., F.I.C., F.C.S. The chair will be taken at 5.30 p.m. by the President, H. Barringer, M.Inst.C.E.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Wednesday, January 9, at the Engineers Club, Coventry Street, London, commencing at 7 p.m. A Lecture entitled "A New Universal Regulator for the Control of Temperature, Pressure, Humidity, &c.," will be given by Mr. T. Lindsay, of the British Area Regulators, Limited.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, January 9, at 6.30 p.m., at the Institution of Mechanical Engineers, Storey's Gate, Westminster, when Mr. A. J. Rowledge will read a paper entitled "Water-Cooled Aero Engines." Members of the Institution of Aeronautical Engineers have been specially invited to attend this meeting and take part in the discussion..

ROYAL AERONAUTICAL SOCIETY.—Thursday, January 10, at 5·30 p.m., at The Royal Society of Arts, 18, John-street, Adelphi, Dr. Leslie Aitchison and Mr. J. D. North on "Materials from the Aeronautical Point of View."

THE INSTITUTE OF METALS: LONDON LOCAL SECTION—Thursday, January 10, at 8 p.m., in the Rooms of the Institute of Marine Engineers, 85-88, The Minories, Tower Hill, E. 1. Paper on "X-Rays and Metallurgy," by Mr. W. T. Griffiths, M.Sc.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, January 10, at 6 p.m., Joint Meeting with the Société des Ingénieurs Civils de France (British Section). Continuation of discussion on Monsieur A. Bachellery's paper on "The Electrification of the Midi Railway."

THE INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Friday, January 11, at 7.45 p.m., in the Albany Hotel, Fargate. Conjoint Meeting with the Institution of British Foundrymen. Paper on "Influence of Casting Temperature on the Physical Properties of Metals," by Mr. F. H. Hurren.

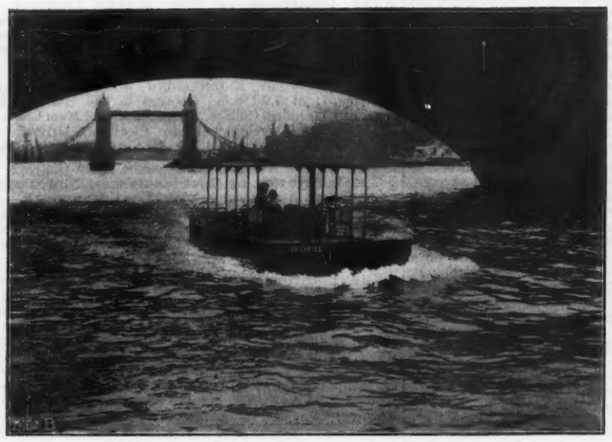
THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 11, at 7 30 p.m., at 39, Victoria-street. Paper, "Concrete Engineering," by Mr. C. O. Mourant, M.I.Struct.E.

VANCOUVER DRY DOCK.—We read in *The Canadian Engineer* that four pontoons have now been launched for the dry dock under construction at the yards of the Wallace Shipbuilding and Dry Dock Company, North Vancouver. These pontoons are required for the first section of the dock. They are each 160 ft. long, 40 ft. wide and 16 ft. deep, and four of them joined together will carry the superstructure of the first section of the dock which will be able to take vessels up to 5,000 tons.

HOTCHKISS HYDRAULIC PROPELLERS FOR 40-FT. TUG.

CONSTRUCTED BY THE HOTCHKISS HYDRAULIC PROPELLER COMPANY, LIMITED, LONDON.

(*For Description, see Page* 13.)



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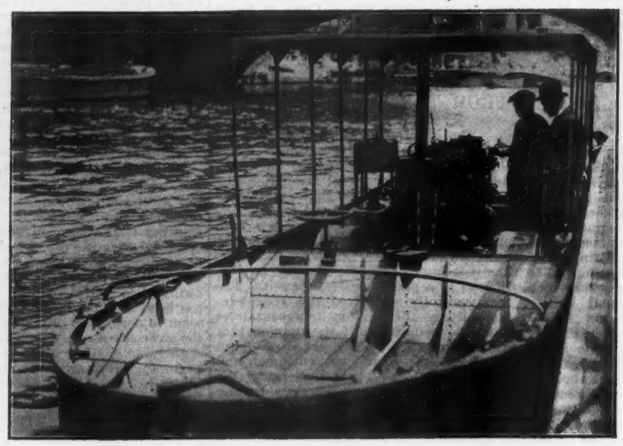

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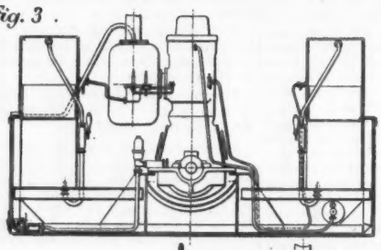

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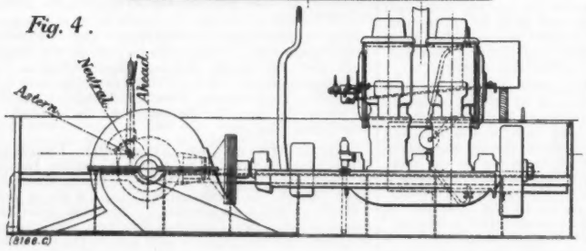

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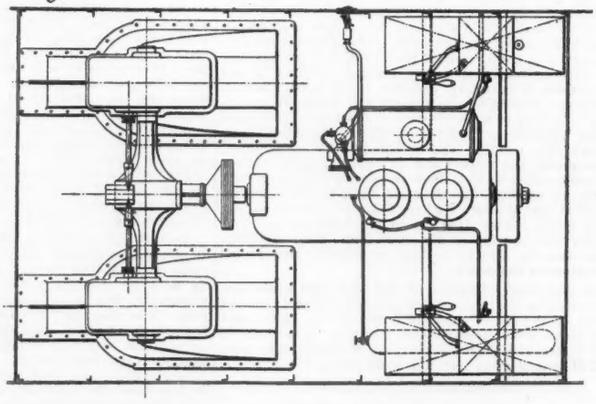

INTERNATIONAL CONFERENCE ON APPLIED MECHANICS.—An international conference on applied mechanics is planned to take place at Delft, Holland, the seat of the Dutch Technical High School, in April next. The British promoters are Professor L. Bairstow, Professor E. G. Coker, Dr. A. A. Griffith, of Farnborough, Mr. R. V. Southwell, of Teddington, and Dr. G. I. Taylor, of Cambridge. This information reaches us from the Executive Committee, Technical High School, 76, Nieuwe Laan, Delft.

THE WHITWORTH SOCIETY.—The first Commemoration Dinner of the Whitworth Society was held at the Holborn Restaurant on December 21, the anniversary of Sir Joseph Whitworth's birthday. Some 100, out of a total of 400 members of the Society, took part in a very enjoyable evening, effective and amusing speeches being made by the President, Dr. H. S. Hele-Shaw, F.R.S., and Sir Henry Fowler, K.B.E. The president pointed out that the objects of the society were neither political, nor technical, but were to recognise benefits received and to help Whitworth men. The custom of drinking in silence to the memory of the founder was duly observed. It was announced that Mr. R. B. Buckley, C.S.I., who, as far as can be traced, is the oldest living Whitworth scholar, would act as the next president, and would be inducted into office at a dinner it is hoped to arrange in connection with the World's Power Conference, June 30 to July 12, at the forthcoming British Empire Exhibition. A "Who's Who" of Whitworth men is in course of preparation, and it is hoped that all holders of Whitworth scholarships or exhibitions, whether members of the society or not, will communicate with Professor D. A. Low, who has the matter in hand. Communications may be sent to Mr. E. R. Dolby, the hon. secretary of the society, at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W. 1.

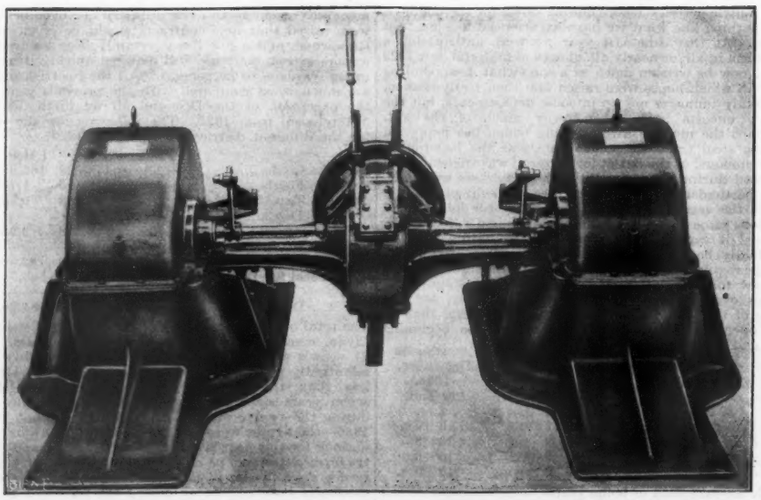

FIG. 6.

SHALLOW DRAUGHT STEAMER "WANHSIEN" FOR SERVICE ON THE YANGTZE-KIANG.

CONSTRUCTED BY MESSRS. YARROW AND CO. (1922), LTD., ENGINEERS AND SHIPBUILDERS, GLASGOW.

(*For Description, see Page* 10.)

Fig. 1. PROFILE.

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Length B.P. 204'·0"
" O.A. 210'·0"
Breadth Mld. 33'·0"
Depth " 10'·6"

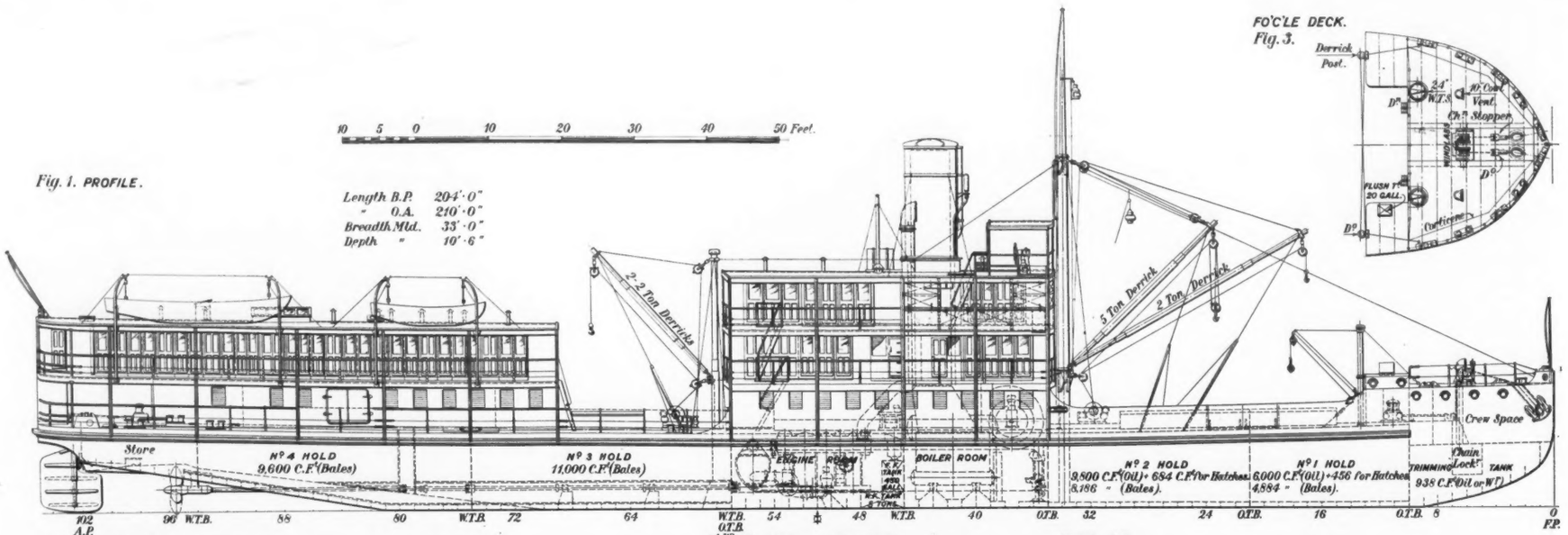

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Fig. 2. MAIN DECK.

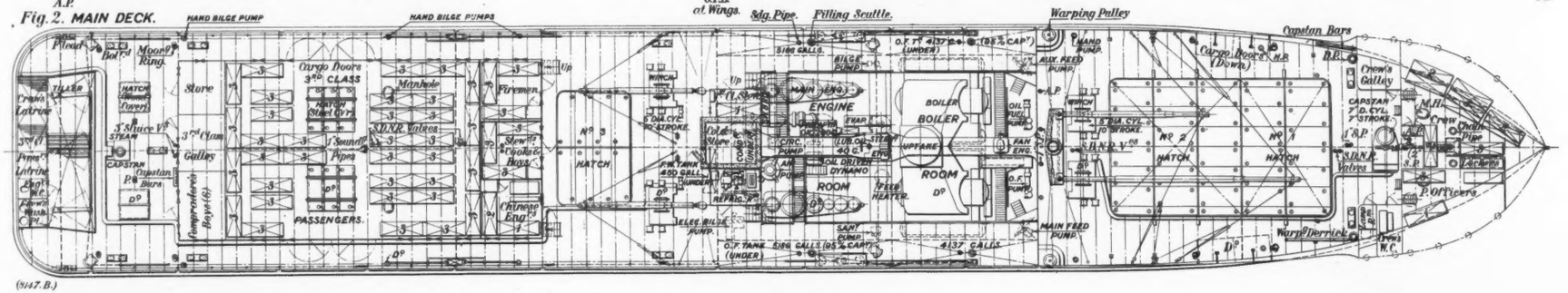


Fig. 4. AWNING & BOAT DECK.

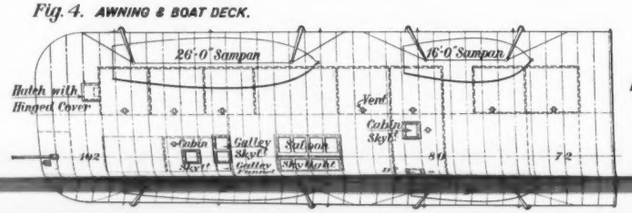


Fig. 5. BRIDGE DECK.

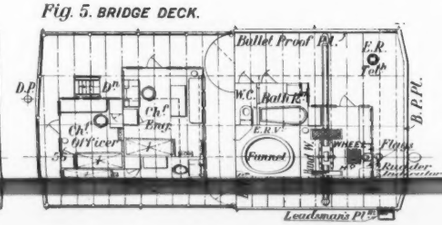


Fig. 8. AWNING D.k & FLYING BRIDGE.

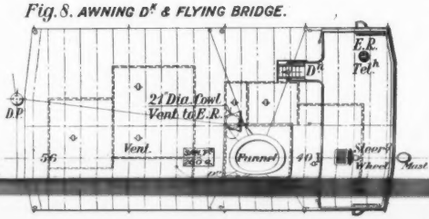
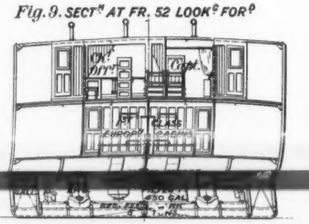


Fig. 9. SECT.N AT FR. 52 LOOK.G FOR.D



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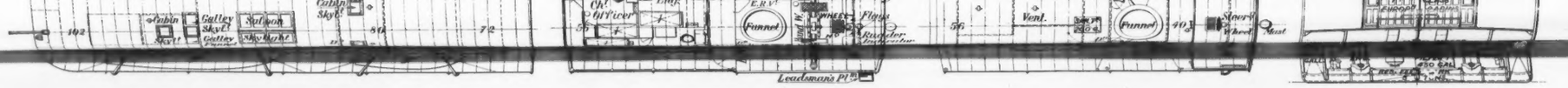


Fig. 6. UPPER DECK

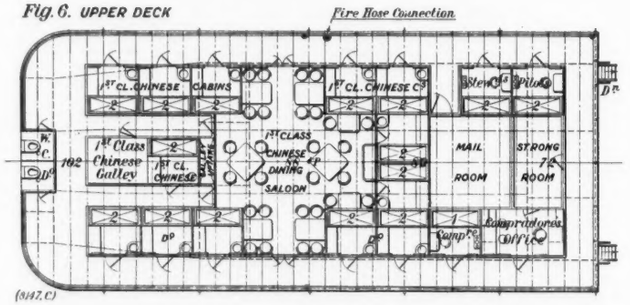


Fig. 7. UPPER DECK.

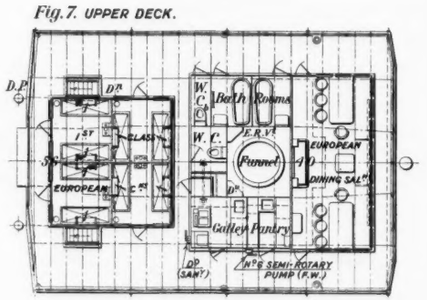
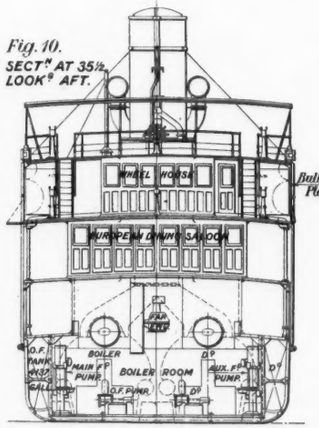


Fig. 10.
SECTN AT 35½ LOOKG AFT.



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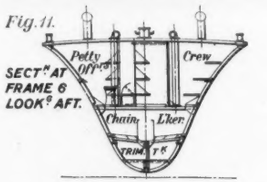
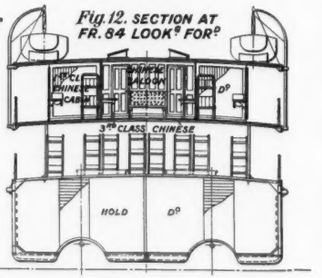


Fig. 12. SECTION AT FR. 84 LOOKG FORD



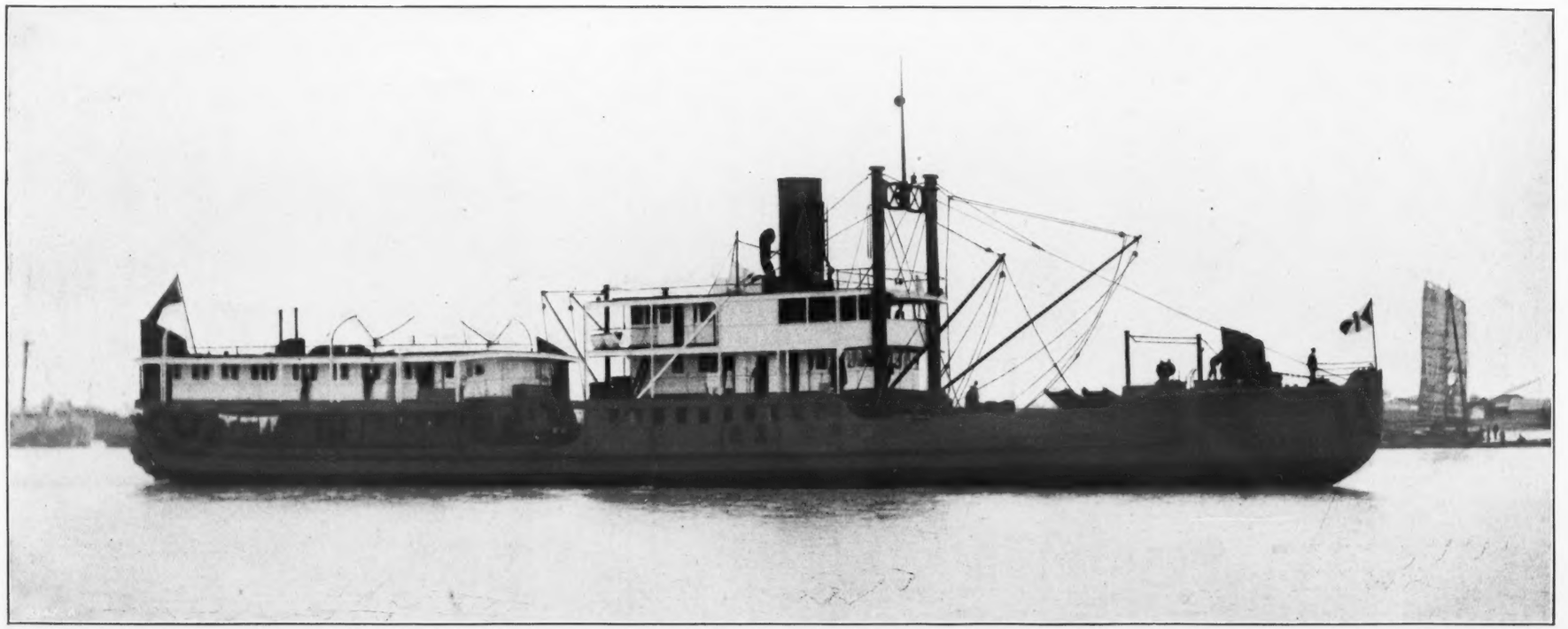


FIG. 13. VIEW OF THE "WANHSIEN" ON THE YANGTZE-KIANG AT SHANGHAI.

ENGINEERING.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

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UNITED STATES : For Subscription, New York : W. H. Wiley, 440, Fourth Avenue. For Advertisements : J. S. Allan, 30, Church-street, New York.

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ENGINEERING.

FRIDAY, JANUARY 4, 1924.

THE OUTLOOK FOR THE NEW YEAR.

THE business of a chronicler is both safer and more respectable than that of a prophet, but of the double role which one naturally assumes at this season the latter half is the more attractive. Especially is this so at the beginning of the year 1924, when, like the double-faced Janus, who gives his name to the new month, one looks before and after. The backward gaze is over a prospect cheerless and grey, while that into the future is, as always, coloured by hope. The past year has but a sorry tale to tell of unemployment and empty workshops, but some hope lies in the fact that nothing in the life of 1923 has become it like the quitting it, and the year leaves unemployment some 23 per cent. better than it found it, and with a considerably more hopeful prospect in the iron and steel and some other industries.

In considering the record of 1923 some satisfaction lies in the fact that, despite the boilermakers' strike, it showed a considerable diminution in working days lost in trade disputes as compared with its two immediate predecessors. The working days lost in the year were some 10,500,000, as compared with 20,000,000 in 1922 and 85,000,000 in 1921. This heavy figure for 1921 was accounted for by the coal and cotton stoppages. Some half of the total for 1923 may be attributed to the boilermakers' stoppage, so that had this foolish strike not taken place the record of the year would have been a remarkably good one. It may be well, however, to temper any satisfaction which this reflection may arouse by remembering that a decrease in labour troubles is a normal feature of periods of bad trade. When there is little to divide there is less readiness to fight about it than when the spoils are large. As the spoils are not likely to be large in 1924 one may venture to hope that the relatively good record of 1923 may be carried on. There are signs of a moderate increase in prosperity in the year, but this increase is not likely to be great enough to eliminate the effect of the lean period we have been passing through. On mere material grounds it is necessary for most of the trade unions to move cautiously in matters which may cost them much money. There is little satisfaction in the suggestion that we are likely to have labour peace simply because the unions cannot afford labour war, but it is useless to deny that the question of union funds has a serious bearing on labour troubles, and it is symptomatic that the New Year begins with a feeling of uneasiness and possibilities of trouble in the coal and railway worlds, both of which were less affected by unemployment during 1923 than the majority of trades.

Although labour matters of necessity occupy an important position in any estimate of the future, most of us are more interested in actual trade prospects and are prepared to leave labour troubles to be dealt with as they may arise, and looking towards the future from this point of view it is satisfactory to see that the total overseas trade of the country showed an increaase of 8 per cent. in 1923 as compared with 1922. This increase was accompanied by an increase in the adverse trade balance of some 26,000,000*l.*, but it is fairly certain that this increase was offset by invisible exports which are now estimated at more than 300,000,000*l.* a year. The exports of 1923 over 1922 showed an increase of something over 50,000,000*l.*, and it is clear that this improvement has contributed considerably to the fall in the total of unemployment. It is fairly certain, however, that our foreign trade cannot recover quickly so long as the present unsettled condition on the Continent of Europe continues. Too much has been made by partisans of the effect of European unsettlement in our workshops, but none the less the effect is considerable. This unsettlement is affecting our customers. An instance is furnished by Brazil, an important coffee-exporting country and normally a heavy buyer from us. Owing to the restricted purchases of coffee in Europe, however, the exchange of the country is very low, and the business we are able to do with it is consequently seriously restricted. Matters of this kind may be offset to some extent by increase of business with the Dominions, but that real European settlement would improve our position there can be little question, and one of the hopes of the New Year must be that the rather more favourable prospects of settlement which the old year furnished may bear some fruit.

Our great and outstanding strength in any revival that may follow a settlement lies in the fact that our finances are in a sound condition and that we are paying our way. It is possible and even probable that our serious unemployment is partly to be explained by our policy of deflation, but if so the only possible reflection is that it is worth it. Every country with an inflated currency must sooner or later face the painful process of deflation or go into what is practically bankruptcy. In two and a-half years our unemployment figures have fallen by 45 per cent., and the importance of the fact that that fall has taken place under a sound financial *regime* can hardly be over-estimated. Our position is such that we can take proper advantage of any trade revival which may now come. Compared with most other of the belligerents of the late war we have pumped out most of the accumulated bilge water and are in a proper position to take full advantage of a favourable breeze. Some of our allies have been able to postpone the period of deflation we have passed through, but it is better to have the rough part of the passage behind rather than before, and the fact that we have passed through our period of deflation forms one of our best hopes for the New Year.

As far as home trade is concerned the whole range of engineering manufacture has suffered particularly badly owing to the disorganisation of methods caused by the war and, in many branches of work, the colossal stocks of manufactured material which were accumulated. The effects of these factors are now passing, but it is only common justice that the special difficulties of the engineering trades should have received some small melioration from the operations of the Trade Facilities Act and other

special efforts to meet the unemployment situation. There is nothing in this Act, nor in any of the special efforts, which deliberately directs their assistance into engineering channels, but the modern position of engineering is such that in any great material work now undertaken a very considerable proportion of the expenditure necessary tends to assist engineers. This is perhaps not very marked in the case of the various road work, but any bridge building, dock work or railway construction is almost entirely carried out by engineering effort, and one of the most satisfactory features of the closing months of the old year lies in the important pronouncements in connection with new works and replacements which have been made by the great railway groups. This work, in addition to the various electrification schemes which are in progress, or prospect, make the new year a very promising one from the point of view of many engineering firms.

The question of electrification in particular forms an excellent illustration of one of the most promising aspects of engineering generally. Such work is one example of the many phases of activity in which the latest methods of the engineer can show such important savings over older procedure that they cannot be neglected and must be considered even in difficult periods. Indeed, the more difficult the period the less can operating companies afford to retain old and inefficient procedure. This point of view is of great importance in connection with shipbuilding which at present is the worst spot in the whole engineering trade. One of its chief hopes lies in the growing recognition by shipowners of the advantages which modern construction and methods carry. Of the total merchant fleet of the United Kingdom only 29 per cent. is under five years old, while the average for the world is 36 per cent. This latter figure is certainly raised considerably by the large modern fleet of the United States, of which 58 per cent. is under five years old, and although it is very possible that an important percentage of this fleet will never sail the sea, it may be taken as certain that the percentage which is retained will be the most efficient percentage. It is not necessary to argue here that the oil engine will form the main marine propelling unit of the future, but it is certain that at the present time it can make a very attractive claim for many types of service, and it is satisfactory to see that at least 26 British marine engineering and shipbuilding firms are now constructing marine heavy oil engines. If with this unit, or in some other way, our shipbuilders can persuade our shipowners to increase their proportion of new vessels from the present 29 per cent. to the 38 per cent. of Holland, it will do much to assist a very distressed branch of our industry.

The electrical trades probably form the branch of engineering which has suffered least from the bad period through which we have been passing, and they at least should be able to look forward to the New Year with fair confidence. In addition to the new railway electrifications to which we have referred, there is very considerable activity in general power station construction both at home and abroad. It is matter both for hope and satisfaction that more than one of the large British manufacturing companies have inaugurated hydro-electric departments and are now building water turbines of large capacity. This class of activity cannot expect to find any important market at home, but much hydroelectric work has been carried out, and is being carried out, in the Empire. Much of the machinery for this development in the past has come from the Continent of America, but there is no reason why Great Britain should not obtain a very considerable part, and any orders which are placed in the future and the commendable enterprise of the firms referred to is likely to be fully rewarded.

In summarising the prospects for the new year it would appear reasonable to anticipate some improvement on that which has just passed, but it is difficult to see any signs of an immediate period of prosperity. We suggested earlier that the increase in our adverse trade balance in 1923 by 26,000,000*l.* was probably covered by an increase in invisible exports, but it is well not to neglect the phenomenon of the exchanges. The New York exchange has moved against us fairly steadily since last March. This may possibly be attributed to European unsettlement, but may on the other hand be partly explained by our increased adverse trade balance. These matters are not capable of definite determination, but if this latter cause is acting it means that we are tending to live on our capital. Any such effect must ultimately automatically correct itself, but it would none the less be very unsatisfactory, as showing that we are not yet doing enough work to cover our consumption of commodities. It cannot too often be repeated that the money we have to spend is the money we earn, and that unless we maintain an output per head at least equal to our pre-war output we cannot retain our pre-war standard of living, much less the improved standard for which every one now looks. The ultimate ramifications of finance are past finding out, but the demand for a higher standard of living must work in the direction of forcing a greater output per head of population. This can only come by improved methods and improved machinery or by much longer hours of work. As the latter will certainly be rejected, the former will automatically be imposed on us, and in this lies one of the best hopes of the engineer. The world has now reached a state in which, without an ever increasing appeal to the engineer, it cannot carry on at the level to which it has raised itself, and if not immediately yet, in the not very distant future very heavy demands must, and will, be made on the engineering factories of the world. That the factories of this country will take their rightful place in that revival British engineers may be expected to make sure.

THE SHANGHAI AND OTHER TURBINE FAILURES.

CONSIDERING the extraordinarily rapid development of the steam turbine, the number of serious accidents has been surprisingly small. A comparatively few years ago a turbine developing 1,000 kw. was regarded as an extraordinary machine, yet to-day contracts for machines to develop 40,000 kw. in a single cylinder would be gladly accepted by half-a-dozen firms capable of executing them. Designers now are dealing with powers and speeds which have no counterpart in any other branch of engineering, and thanks to the help of the metallurgists, chemists and other auxiliary workers are able to make rapid and continuous progress. The history of the art of turbine building is probably freer from records of disaster than that of any other branch of heavy mechanical engineering, but like every other constructional art its development has been marked by misfortunes wnich all the care and skill in the world have been unable to prevent. Practice, in a new art, always is, and must be, ahead of the theory, for theories cannot take account of facts until they have been discovered, and the discovery of unexpected conditions may not arise except by a disastrous failure of the mechanism in question. This was the case in connection with the now well-known phenomenon of the axial vibration of turbine wheels at high speeds, which has been responsible for quite a lot of the costly mishaps which have occurred. Nobody imagined that a very stiff disc of steel, particularly when subject to the great radial stretching forces developed by its high speed, could possibly vibrate sufficiently to fatigue the metal of which it was composed, yet the inexorable logic of facts proved that this might happen, and the first evidence of its happening was only too frequently a wrecked turbine.

The designer has also to contend against factors which no theory can take into account, namely concealed flaws in material, defects of workmanship and unsuitable treatment, both mechanical and thermal. That accidents have not been more common is a tribute to the turbine-building firms, but when they do occur it is not surprising that they are of a catastrophic character. There are in service to-day numerous machines developing 10,000 kw., or more at 3,000 r.p.m., and with rotating elements weighing very many tons revolving at this speed the kinetic energy stored is enormous. The blades are travelling with a velocity well on towards that of a rifle bullet, and any rupture of the material under the centrifugal stresses to which it is exposed is almost bound to cause widespread disaster. These are the conditions of normal running, but there is always the risk that some mechanical injury to, or defect in, the governor gear may cause overspeeding of the turbine, resulting in the stresses increasing until something gives way.

The only collected list of turbine accidents which has yet been published so far as we are aware, is that given by Mr. K. Baumann in his paper read before the Institution of Electrical Engineers on April 7, 1921, and published in our columns on May 20 of that year. He then gave particulars of 17 cases with brief notes of the causes of failure and extent of damage. Seven of the machines are stated to have been "wrecked" or 'completely wrecked" and what these expressions mean in respect of a turbine disaster will be understood fully only by those who have seen what a bursting turbine can do in the way of destruction. It is noteworthy that no less than six which come under the category of wreckages failed by the bursting of a turbine disc, the one exception being a machine in which a disc came into contact with a diaphragm causing the latter to revolve till it burst through the casing. The standard reaction type of machine is, of course, free from the possibilities of disasters of this spectacular nature caused by the bursting of discs; and, indeed, it may be said that no really serious accident had ever occurred to a reaction machine until that which took place last November in Shanghai. Stripping of blading was usually the extent of the damage to such machines and experience of millions of horse-power, ashore and afloat had led to the belief that this annoying but remediable trouble was about the worst that could happen to reaction machines.

The disaster at Shanghai breaks a record of extraordinary excellence. Letters and newspapers from the Far East dealing with the occurrence have now reached this country, but even yet it is not known to what cause the failure was due. The machine was constructed to develop normally 20,000 kw. at a speed of 1,500 r.p.m., and an examination of the drawings which were published in our issue of July 13 last will show that at the proper speed no part of the rotor was stressed beyond what the most conservative experience would consider reasonable. Unless there was some hidden flaw in the forging, it seems incredible that the rotor could burst unless driven at a speed which is equally incredible under the circumstances of the accident. The tip speed of the longest blades was normally only 740 ft. per second, which may be compared with the velocity of 1,000 ft. per second frequently reached in certain types of turbines.

The builders of the machine, Messrs. C. A. Parsons and Co., Ltd., have kindly placed us in possession of such information as has yet reached this country concerning the disaster. It appears that the turbine had been running for a week, drying out the alternator, but on the morning of November 15, when the accident occurred it was uncoupled from the alternator for balancing purposes. The turbine rotor had been running a little time when the accident occurred, so far as is known, without warning of any sort. The erector and two other European engineers on the spot were unfortunately killed by flying fragments, so that there is no person who can give an exact statement as to what was occurring at the moment. There is evidence tending to show that the machine could not have been running above its normal speed, and the experience of the ill-fated erector is a sufficient guarantee that no dangerous speed would have been permitted. The rotor shaft at the high pressure end was found after the accident to have fractured transversely through a part over 20 in. in diameter, and also to have split in halves longitudinally. The machine was erected and tested under steam at Newcastle before despatch, and one of the illustrations in our article referred to above shows it on the test bed. The design, moreover, embodied no departure from Messrs. Parsons' usual practice.

Immediately upon learning of the disaster, Messrs. C. A. Parsons and Co. cabled accepting full responsibility and undertaking to do everything in their power to mitigate the consequences to the Municipality of Shanghai. Another machine was at once put in hand to replace that which had been destroyed, and two experienced engineers at once left for Shanghai to render what assistance they could.

The fullest inquiry will be held into the cause of the accident, and until the findings are known, it would be premature to indulge in speculation as to possible causes. The account in the local paper gives a general idea of the scene after the accident. The roof, about 60 ft. above the floor level was perforated by flying fragments, and a large part of one of the walls was knocked out. The alternator was uninjured and very slight damage had been done to the condensing plant. The enormous rush of steam into the engineroom naturally made the confusion worse at the moment, but matters were quickly brought under control again, and the supply of power was restored in about 2 hours.

We have frequently called attention to the extraordinary progress made by the Shanghai Municipal Undertaking under the management of Mr. T. H. U. Aldridge, who will receive the sincere sympathy of all engineers in the calamity which has befallen his new station. It was not until 1904 that the output of electricity in Shanghai reached a million units per annum. The average annual increase in output from that time to the present has been no less than 36 per cent., and during 1922 the last year for which complete returns are available, the output was practically 252,000,000 units, with a load factor of 51 per cent. We have in Great Britain nothing to compare with such figures. According to the latest returns Manchester, our largest municipal undertaking, is only producing 186,000,000 units, and Glasgow, the next largest, only 142,000,000 units per annum, the load factors in both cases being below 30 per cent. The energy and skill which have given Shanghai so proud a position in electrical matters can be relied on to mitigate as far as possible the consequences of the loss of so important a generating unit, and if the technical inquiry which is being held results in knowledge which will render failures of large turbines even more infrequent than they now are, something at any rate will have been gained by the deplorable accident at Shanghai.

THE LATE M. ALEXANDRE GUSTAVE EIFFEL.

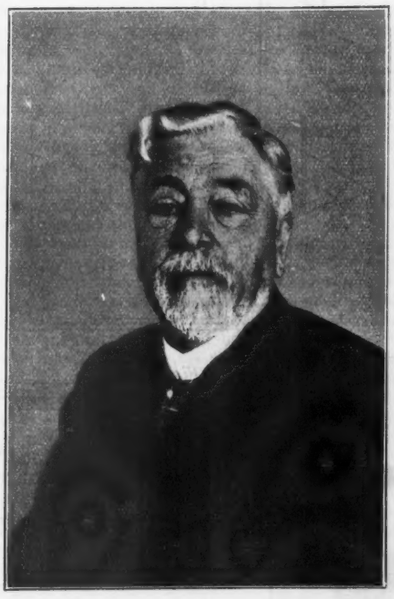
WE regret to have to report the death, which occurred at his Paris residence, 1, Rue Rabelais, on Friday last, December 28, of M. Alexandre Gustave Eiffel, the celebrated French civil engineer, well known in every part of the world since 1889, when he designed and built the 300 m. tower which formed the most conspicuous manifestation of civil engineering skill shown at the Paris International Exhibition of that year. Before that date, commencing as early as the late 'sixties of last century, examples of M. Eiffel's skill in the form of bridges and other structures, were frequently met with on the Continent of Europe and in countries overseas—and this class of work he continued to carry out with success down to the present times—but the construction of the Eiffel tower is the event which will perpetuate his name, although many of his other structures are quite equal, if not superior, to it as engineering accomplishments.

M. Eiffel, whose photograph we reproduce on the present page, was born at Dijon on December 15, 1832, and had thus just completed his 91st year. He received his primary education at a college in his native city, then at the Lycée Ste Barbe, Paris. His vocation having always been that of an engineer, he entered later the Ecole Centrale des Arts et Métiers, the well-known Paris technical school, where he selected the civil engineering courses. He completed these in 1855, and, shortly after, in 1857, he became a member of the Société des Ingénieurs Civils de France, and was therefore one of the oldest members of that institution.

One of the first responsible positions held by M. Eiffel was that of resident engineer—in 1858—at Bordeaux, for the construction of the iron bridge in that city over the River Garonne, the pier foundations being made by the aid of compressed air 82 ft. under water level; this was one of the largest iron bridges built up to that date. M. Eiffel collaborated effectively in its construction and carried the work through to a successful issue.

Following this, the subject of our memoir was engaged as engineer by several other French contractors until a few years previous to 1867, the date of one of the Paris International Exhibitions, when he contributed to the designing, building and testing of the structure forming the machinery hall of that exhibition. This work was the subject of a pamphlet which he wrote, dealing with the modulus of elasticity of built-up members forming part of structural work.

Shortly after this date, M. Eiffel put down works at Levallois-Perret, a suburb of Paris, and among the bridges and structures which he designed and carried out at that time may be mentioned bridges for the railway from Poitiers to Limoges, 226 tons; the Neuvial and Sioule viaducts, 1,100 tons; structural work for the church of Notre-Dame des Champs, Paris, 176 tons, and for the Paris synagogue, 248 tons; besides several gas and other works plant. In 1868, the Orléans Railway Company requested M. Eiffel to prepare designs for the construction of viaducts supported on iron piers for sections of their lines at which the height to be bridged was a comparatively great one. The railway company accepted his designs for the Sioule and Neuvial



THE LATE M. ALEXANDRE GUSTAVE EIFFEL.

viaducts above referred to, the larger of the two being the Sioule; it is carried on two piers, the height of which is 167 ft., both piers being built-up of cast-iron columns connected together by latticework formed of wrought-iron bars. This type of bridge construction M. Eiffel developed in subsequent contracts, but substituted wrought-iron members for those of cast-iron, and built the piers of four box-shaped members open towards the inside of the pier. These members were connected by long wind-bracing, square in section, capable of resisting both compression and tension. For greater heights, 330 ft. and more, M. Eiffel patented in the earlier years of his business career a number of improvements in bridge pier construction and bridge building generally; he also devised means for placing bridge floorings in position by means of roller frames which have since been generally adopted. He used these frames for the first time in 1869 for the building of the Sioule viaduct.

Down to the year 1887 when he commenced the construction of the Paris 300-m. tower, M. Eiffel had built iron and steel bridges and structural work having a total weight of over 100,000 tons, in which railway bridges accounted for about 38,000 tons, road bridges for about 12,000 tons and structural work for about 44,000 tons, the total weight not including a number of civil engineering works which also comprised masonry, foundations, &c., apart from their iron and steel elements, and not including either the Eiffel Tower, whose weight is 7,800 metric tons. We cannot in this brief notice enter into the details of all the constructions carried out by M. Eiffel, and we shall therefore limit our remarks to a few data concerning the most important works. Among these we may place the Tardes Viaduct, on the Montluçon-Eygurande line, in the centre of France, erected over a deep valley, the rail level being 263 ft. above the bottom of the river. The platform has a total length of 820 ft., the bridge having three spans, a central one of 340 ft. and two side ones of 240 ft. each. It was built in 1883, and weighs 1,217 tons. Two other important bridges were those on the Tagus, on the Caceres Railway, Spain, 1,204 ft. in length, built in 1880, and the Vianna Bridge, on the Minho Railway, Portugal, 2,414 ft. in total length, and weighing 2,338 tons, carried on nine masonry piers.

Among the interesting arched bridges built by M. Eiffel we may mention the road bridge at Szegedin, Hungary, constructed in 1881. It has a total length of 1,990 ft.; the span over the river consists of a parabolic arch, having a span of 361 ft. and a rise of 28 ft. only, giving the unusual ratio of rise to span of 1 in 13. The bridge is carried on masonry piers and the weight of the iron portion is 2,050 tons. Another arched bridge by M. Eiffel's firm is that over the Douro, at Porto, for the Portuguese railways. This was built as early as 1875. The railway line is 200 ft. above the level of the river, and the waterway, 525 ft. in width, is crossed by one central arch. The bridge floor on both sides of the arch is carried on lattice piers. The bridge has a total weight of 1,450 tons. Another work of the same kind, but of greater importance, built in 1882, is the Garabit Viaduct, on the South of France Railway system, and weighing 3,248 tons. It crosses the valley at a height of 400 ft.; it has a total length of 1,850 ft., and in addition to the central arch the structure includes five piers, the highest having a height of 294 ft. The arch has a span of 541 ft.

The above brief notes will give an idea of the work carried out by M. Eiffel in the course of his career. We need not enter into any details of the Paris tower, as this is well known; it is a landmark in the French metropolis and can be seen for miles around. It served its purpose during the exhibition of 1889, but for several years afterwards it was considered rather in the light of a "white elephant." When it was first contemplated, its future uses were summed up as follows: Astronomy; the study of laws of refraction, spectroscopy, telluric rays, Vegetable chemistry; the study of vegetation at a height of 300 m. Meteorology; to investigate wind forces, temperatures, hygrometry, air currents, &c. Physics; deviation of a body falling in space, &c. War; to serve for optical telegraphy and as an observation post. It has been used for these purposes and for many other observations and researches, but since the advent of wireless telegraphy and telephony it has proved a most invaluable building, one which has rendered marked services to the French nation and is likely to continue to do so for many years to come. During the war it was provided with a number of quick-firing guns for use against the enemy's aircraft. We have already described the Eiffel tower in detail in former volumes.*

M. Eiffel was president of the Société des Ingénieurs Civils de France in 1889, and was made an honorary president of that body last year. His other French titles were very numerous. He was also honorary member of our Institution of Mechanical Engineers, of the American Society of Mechanical Engineers, New York, and of similar institutions in Holland, Russia, Spain, Belgium, &c. His work at home and for foreign countries brought him a number of distinctions; he was an officer of the Legion of Honour, Officer de l'Instruction Publique, besides being a Knight and Commander of many foreign orders. M. Eiffel also received the Langley gold medal of the Smithsonian Institution, Washington. He contributed a large number of papers to the French Society of Civil Engineers, and to other institutions, describing his civil engineering works,

* See ENGINEERING, vols. xliii, p. 403; xlv, p. 594; xlvii, p. 428; xlviii, pp. 39 and 77.

his researches on aerodynamics at the Eiffel tower, and meteorological and other investigations. He was present at the meeting in Paris in 1922 of the Institution of Mechanical Engineers, and received the members on that occasion at the tower. He was invariably of a kindly disposition and had hosts of friends in every quarter of the globe.

THE PHYSICAL AND OPTICAL SOCIETIES' EXHIBITION.

THE fourteenth annual exhibition of electrical, optical and other physical apparatus, arranged by the Physical Society of London and the Optical Society, was held on Wednesday and Thursday, January 2 and 3, from 3 p.m. to 10 p.m., at the Imperial College of Science and Technology. Mr. F. E. Smith, F.R.S., senior secretary of the Physical Society, having resigned last October owing to pressure of work, the arrangements had been made by his successor, Professor A. O. Rankine, of the College. There were a few new names among the 55 firms represented—the number has hardly varied of late—including three bookselling firms, the Cambridge University Press, the Wireless Press, Limited, and Messrs. H. K. Lewis & Co., of Gower-street.

Two discourses were delivered at the exhibition on each day. Mr. H. B. Grylls demonstrated the Heape and Grylls Rapid Cinema Machine, which can take photographs at rates varying from 500 per second to 5,000 per second, and Sir Richard Paget, Bart., gave his remarkable demonstrations of "The Nature and Artificial Production of Human Speech (Vowel Sounds)," to which we have referred on other occasions.

The chief novelties of Messrs. Adam Hilger, Limited, were the optical gauge illustrated on page 10 of this issue, and the Müller X-ray spectrograph, which will be described later. Demonstrations were given of Professor Coker's apparatus for determining stresses, of the Hilger audiometer, of a new electrostatic oscillograph for transformers, and of applications of the exceedingly thin celluloid films of the firm, which were introduced by Professor R. W. Wood. In the ordinary Michelson interferometer arrangement a second compensating mirror is needed to suppress colour effects; when one celluloid mirror is used the interference bands are white; this is an advantage for échelon measurements. Another of these films was so thin (about 0·1 of a wave-length thick) that black spots appeared on it as in soap bubbles. The tetragonal glass prism, also exhibited, returns any ray of light falling upon it; thus an observer A moving in front of the prism always sees himself in it, and an observer B also sees himself, but A cannot see the image of B any more than two people standing close to one another see the same rainbow; the peculiar reflection described was utilised for secret signalling during the war.

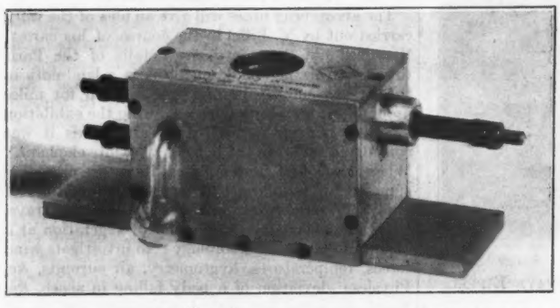


FIG. 3.

Photographs displayed showed the visible spectrum of hafnium as taken by Hansen and Werner with an E 1 Hilger spectrograph, and the fine spectra of iron, carbon and silicon obtained by Mr. F. Simeon, of the staff, with their vacuum spectrograph; these spectras were mentioned by Professor Fowler in the discussion on spectra at the Liverpool meeting of the British Association.* Mention should also be made of the collection of the much-appreciated scientific publications on optical instruments and methods of their use prepared by members of the research staff of Messrs. Hilger.

Kinematic demonstrations of the manufacture of a photographic lens by means of the Kalee Indomitable Projector were given by Messrs. J. H. Dallmeger, Limited, whose new high-speed camera is fitted with an f/29 Dallmeger pentac anastigmat lens of the largest aperture regularly manufactured. This remarkable camera is provided with quick-wind self-capping focal-plane shutters and other devices for working at speeds from $\frac{1}{8}$ second down to $\frac{1}{1,000}$ second.

Messrs. C. Baker demonstrated the grinding, polishing and mounting of microscopic lenses. Of their varied exhibits we notice the ultra-condenser, an inexpensive apparatus of the dark-well type fitted with a quartz window by means of which liquids and gases can be studied for Brownian movements.

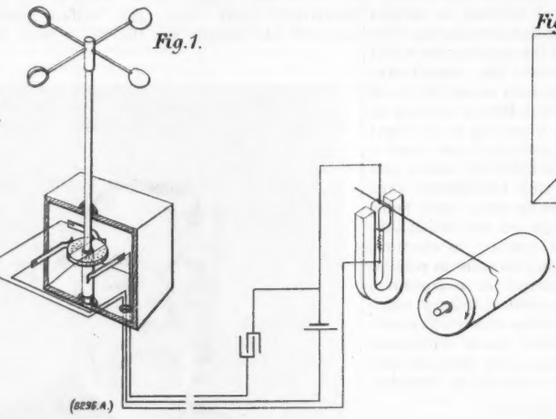
Notable also is their reflex drawing apparatus, in which instrument—a *camera lucida*—the horizontal beam of a lantern is sent through a condenser and a microscope into a prism which reflects the rays downward to throw a magnified horizontal image ready for drawing on a sheet.

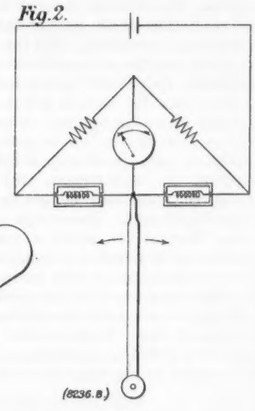
The Lewbeck micrometer of Messrs. R. and J. Beck is another useful novelty for the engineer. When the diameter of a wire or fibre (down to $\frac{1}{50,000}$ in.) is to be determined, the wire is suspended between the condenser and objective of a microscope and projected into a box, in which the wire appears as a thick vertical band crossing a magnified scale; a magnification of 1,000 is obtained, and the wire is not flattened or strained during the measurement. The Beck radial research microscope and outfit is a more elaborate, but convenient, combination of miscroscopes, mounted on a turntable, and a camera; the microscope may also be mounted in a cradle so as to remain in focus in any position when once adjusted.

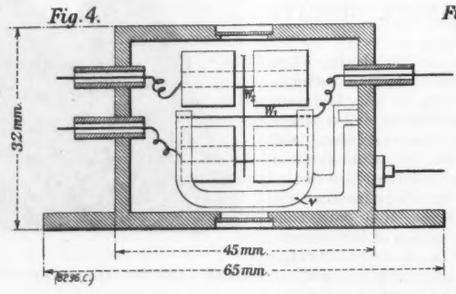
In the new original recording anemometer of the Cambridge & Paul Instrument Company, the condenser discharge method is utilised for obtaining continuous records of a standard Robinson anemometer on a Cambridge thread recorder. Diagram Fig. 1 will explain the simple arrangement. The shaft of the cup-cross bears a commutator disc, which consists of two conducting segments separated by an insulating bar. Two spring contacts bear against the disc, a third contact bears against the shaft, three wires lead to a condenser of 7½ microfarads, a battery of 2 dry cells, and the galvanometer and thread recorder. The condenser is alternately charged and discharged at a rate proportional to the anemometer speed. A record is obtained every minute or every half minute, and the galvanometer gives the true mean of the last 15 secs. The records produced consist of a number of dots, and they clearly show the fluctuations of the wind speed, whilst the ordinary inking devices for drawing wind curves often become easily smudged and hardly admit of tracing the different gusts.

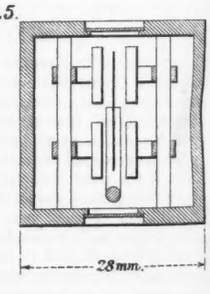
The hot-wire micrometer of the same firm exemplifies a novel application of the katharometer principle of Dr. Shakespear, in which two small resistance coils are placed within two cells, charged the one with a standard gas and the other with the gas to be tested. The coils are electrically heated, and the purity or percentage of the gas under test is deduced from the comparative rates of cooling of the coils which form arms of a Wheatstone bridge. In the arrangement illustrated in Fig. 2 the small movement to be measured or indicated shifts the midpoint between the two coils either to the left or right. When the movement is to the left, the right hand side coil will be opened out, and the left-hand coil will be closed up; the former will therefore cool more rapidly, though both are in the same gas (*e.g.*, air). The arrangement is utilised, for instance, for the electric transmission of a pressure difference, *i.e.*, for determining the rate of gas flow in a main. Two Pitot tubes are mounted in the main; the end of the one tube is connected through a Bourdon tube to the lever of our Fig. 2, which will therefore be moved, pulling one of the coils in the direction of its movement. At the exhibition the instrument was simply shown mounted as a hot-wire micrometer for measuring small distances by means of turning milled heads. The bridge galvanometer magnifies the original movement a thousand times.

The third novelty of the Cambridge and Paul Instrument Company, illustrated in Figs. 3 to 5, is the patented invention of Professor F. A. Lindemann, F.R.S., of Oxford, an electrometer especially designed to eliminate the temperature fluctuation troubles to which electrometers with suspended threads—the Einthoven string electrometer not excepted—are subject. The electrometer is intended for photo-electro and ionisation measure-









* ENGINEERING, October 5, 1923, page 424.

ments, and does not require a high potential range; thanks to its neat, exceedingly compact and simple construction, it measures within 0·001 of a volt. As the photograph Fig. 3 shows the instrument is merely a small rectangular box of aluminium, out of which three terminals and a drying tube, charged with phosphorus pentoxide, project. Inside is a solid quartz rod bent to a U. Across the hoop of the U is horizontally stretched a fine quartz thread W_1 to which is attached the vertical quartz thread W_2, about 15 mm. long. W_2 is really a double thread, consisting of two straight fibres placed a distance of 0·003 mm. apart. The pointer or needle W_2 bears at the top a short bar which serves as index for the microscope, under which the electrometer is placed. The needle W_2 moves in the field of two pairs of brass plates (each plate is cut in halves, so that there are four pairs), which are diagonally connected, as in a Dolezalek quadrant electrometer, and charged to about 100 volts. A movement of the needle of 1 mm. would correspond to a potential difference between the needle and the field of 1 volt, and 0·001 volt can be read off. The period of the moving system is 1 sec. The quartz fibres, we should add, are covered with a silver film by kathode volatilisation. Professor Lindemann has also improved the construction of a string electrometer in such a way that it can be used on a microscope stage without further fittings.

(To be continued.)

NOTES.

The New Factory Legislation.

The Home Office have issued to the occupiers of factories throughout the country a circular letter drawing attention to the new factory legislation which has been incorporated in the Workmen's Compensation Act, 1923. The circular is accompanied by a specimen print of a summary of the requirements of the Workmen's Compensation Acts with regard to the giving of notice of accidents and the making of claims, and the procedure to be followed in cases of industrial disease. The object of the summary is to let the workmen know what steps they should take to give notice of accidents to their employers and to make their claims for compensation within the proper time. The occupier of the factory must keep the summary posted up in some conspicuous place. There is also a specimen of the accident book which is to be kept at each factory so that particulars of accidents may be entered in it by the injured workman or someone on his behalf. Such entries are to constitute notice to the employer. There seems to be confusion in the minds of some employers regarding the object of this book. It should be clearly understood that it is merely a book in which the injured workmen or their friends may enter particulars of accidents with the object of giving to the employer notice of the accident, for the purposes of the Workmen's Compensation Act. This has nothing whatever to do with the employer's duty of notifying accidents to the Inspector of Factories, and the duty of keeping a record of the cases treated in the factory ambulance room. The circular also gives particulars of the prescribed contents of the first aid boxes.

The Scientific Novelties Exhibition.

The members of the scientific staffs of the London colleges have organised a very attractive exhibition as a means of raising a contribution from science to the King Edward Hospital Fund for London. The exhibition is held in King's College, Strand, and remains open until Wednesday, January 9. In it there are displayed and demonstrated many fascinating pieces of apparatus used to show how physical actions can be used in the provision of instructive entertainment. Professor Ernest Wilson gives short lectures on high-tension electrical discharges, and after discussing atmospheric electrical phenomena produces an experimental lightning discharge, the effect of which is made more realistic by the accompanying thunder. The manner in which the rotating magnetic fields, caused by the passage of alternating currents through sets of coils in combination, can be made to keep in a state of spinning such metallic articles as coins and tops is a spectacular demonstration which appeals to the many young people who visit the show. The Engineering Society of King's College have arranged an attractive show of wireless telephonic and telegraphic apparatus, in which some of the newer appliances are shown, such as the Brown Frenophone loud speaker and a new Marconi magnetic drum recorder. The engineer in embryo and his older friends have also an opportunity of learning something at King's College of the methods adopted in testing the strength characteristics of the materials adopted in engineering, for Professor Jameson and Mr. Lobban have arranged an almost continuous series of demonstrations in the engineering laboratory. The physics side of the show is particularly interesting, and the staffs and students of the various colleges have shown a healthy rivalry in their efforts to obtain the most effective and appealing display of particular physical phenomena. The natural sciences have not been neglected and for those interested on the development of mankind through the ages, the facilities are provided for a comparative study of the skulls of early types and those of more modern times.

Chartered Civil Engineers.

That engineers are not generally accorded the position which the importance of their calling warrants, has frequently been pointed out in presidential addresses and other semi-official engineering pronouncements, and the subject has been discussed among engineers over many years. We do not know, however, that the public in general has ever displayed any lively interest in the matter, and it has long been clear that any improvement in the status of engineers as engineers, could come only from their own efforts. The real basis of the difficulty turns on the question of a name, and as long as any one with no credentials of any kind is free to describe himself as a "civil engineer," it will not be possible to expect the term to carry much weight. Among engineers themselves, and to a small extent among the educated classes generally, the standing of an engineer is indicated by the institutions of which the letters after his name indicate membership, but the relative status of such institutions seems surprisingly little recognised even in general intellectual circles. In view of these circumstances the step which has been taken by the Institution of Civil Engineers in connection with its third supplemental Royal Charter is probably destined to have important influences in the future. This supplemental Charter gives members and associate members of the Institution authority to describe themselves as "Chartered Civil Engineers." The word "Chartered" in other connections has attained a position of authority in the public mind, and it is probable that the new description will lead to a better recognition of the real standing of the man who is able to use it, while it will tend to prevent the outsider unfairly trading with the title "civil engineer." There is an aspect of the new arrangement, however, which, while of no great importance to the public, is none the less of considerable domestic interest to members of the Institution. It will be clear from what we have said that both members and associate members of the Institution of Civil Engineers are now entitled to describe themselves as Chartered Civil Engineers. The new term thus places them on an equality from the point of view of an outsider, and experience only can show if this difficulty is of any practical importance. After all, the status of the leading men in any profession is determined by their individuality and the work they have done, and the names of the leading members of the Civils are likely to continue to be their best description. If with less known men the practice of using the descriptions M.Inst.C.E. and Assoc.M.Inst.C.E. in conjunction with the new term is followed, confusion should not arise. The Institution of Civil Engineers was founded in 1818, and it has from the first taken the premier place amongst institutions of its class. It has always during its long and honourable career made it one of its chief duties to do everything in its power to raise the status of the engineering profession and to secure that its corporate members should really be entitled to the titles they bear. By so doing it has performed a valuable service to the public, and the powers granted to it by the new supplemental Royal Charter have been well earned.

Imperial Air Transport.

A great step forward in the development of aerial navigation by heavier-than-air machines has been made possible by the agreement recently made by the British Government with the British, Foreign and Colonial Corporation, Limited, for the formation of a subsidised company to deal with the services in Europe. The scheme was outlined in a publication of the Air Ministry which was issued on Friday, December 28. In the beginning of such activity as the creation of a transport service by aeroplanes the expenditure will be large and the returns but small. In such circumstances, since the prosecution of these endeavours is of great national importance, some type of subsidy is essential. The total sum to be provided by the Government is 1,000,000*l.*, and the grant is to be divided over a period of ten years, in diminishing sums, ranging from 137,000*l.*, which will be paid in each of the first four years, to 32,000*l.* in the final year. Effective provisions are made in the agreement that the later grants will only be made after it is established that defined progress has been attained. An important section in the agreement relates to the absorption of the British concerns now operating on the various aeroplane routes, and in this respect proposals have been made for the acquisitions of the rights and businesses of the following companies: Handley Page Transport, Limited, the Instone Air Line, Limited, Daimler Hire, Limited, and the British Marine Air Navigation Company, Limited. All directors, two of whom are to be Government nominees, and all shareholders of the new Imperial Air Transport Company, Limited, must be British subjects, and the pilots must all be members of the Air Force Reserve or the Auxiliary Air Force. The initial share capital of the company is to be not less than 1,000,000*l.*, and it has been agreed that the profits will be allocated on a system which shows some variation from that originally suggested under the Hambling scheme. Ten per cent. on the paid-up capital will be distributed among the shareholders, and after that any balance that is available will be divided into thirds. One of these will be used in repaying the yearly subsidies, another will be transferred to the development and improvement fund of the company, and the last will be distributed as further dividend among the shareholders. It is a matter for congratulation that a scheme has been devised which seems to be attractive to the promoters, satisfactory to the public and shareholders and with effective control by the Air Council.

LITERATURE.

Gas Manufacture.. By W. B. Davidson, M.A., Ph.D., D.Sc., F.I.C., Consulting Chemical Engineer, Chief Chemist City of Birmingham, Gas Department. London: Longmans, Green and Co., 1923. Price 21*s.* net.

Several books have appeared lately dealing with the technology of gas manufacture, and the mechanical aspect may appear to have been sufficiently discussed. Dr. Davidson, however, contrives to give to his work a somewhat different character by attaching greater prominence to the chemical problems that arise, and by discussing other matters only remotely connected with gas manufacture, properly so-called. The introduction of such a variety of subjects is not altogether happy, for the effect is to make the treatise one of general reference to gas topics. As a consequence, the processes in which the gas engineer is most closely concerned are apt to become confused by the mass of extraneous matter, treated more or less superficially. But perhaps the more the plan is changed the more it remains the same, for a not inconsiderable section of the whole is devoted to the description of various arrangements of carbonising plant, with a wealth of detail that permits a very complete survey of modern processes and the examination of the application of many ingenious devices. A comprehensive review of the conditions of gasification from time to time is a necessity, for the value attaching to specially prized processes is constantly varying, according to the requirements of the

moment and especially with the urgency of the demand for by-products. The perpetuation of obsolete methods and the adherence to a stereotyped procedure are to be deprecated, and the continual examination of advanced practice is the surest means of arousing the energies of officials, who need to be ever on the alert in the midst of variations that appear slight, but may be of great pecuniary value on account of the magnitude of the operations involved. The condemnation pronounced against certain innovations has often proved too precipitate, and the judgments on proposals passed in pre-war days have been overthrown in the light of later experience. The economy and practicability of low-temperature carbonisation of bituminous coal are among those questions that call for re-examination. The whole value of the method is not exhausted by an inquiry into the quantities of tar or ammonia derivable at various temperatures. The author who expresses an outspoken opinion on many controversial points is rather reticent on this question of the day, and in his remarks is apparently quoting from authority rather than relying upon experience derived from large scale operations.

At the outset, a long chapter is devoted to the consideration of some elementary principles of chemistry and physics, in order to provide the information that Dr. Davidson thinks necessary for the proper comprehension of the behaviour of gases. Possibly he is right, but definition and description are at best poor substitutes for laboratory practice. The effect of this preliminary chapter, 10 per cent. of the whole, is to overweight the book for those who have mastered this early stage, and it might further be urged that those who are unfamiliar with the grammar of the subject are not in a position to benefit by the chemical formula and reasoning presented in the section on the constitution of coal gas and later chapters. We should gather that the author's experience of the scientifically-trained assistant has not been happy, and that he does not entertain a high opinion of the capacity of the chemist in the conduct of operations in the works. For instance, in the matter of gas-fired settings, Dr. Davidson debates whether it is better to employ a trained chemist or capable workman, and decides in favour of the workman, concluding that experience without scientific knowledge is better than scientific knowledge without experience. If this decision is justified one may well ask whether the university training, so confidently urged as the remedy of many evils, is the best that can be recommended.

Subjects of mere academic interest disappear rapidly, when the author attacks the practical side of gas manufacture and discusses the principle of carbonisation in connection with the construction of suitable plant. His experience gained at the Birmingham works has made him familiar with the details, and enabled him to acquire much practical information of which he gives the reader the benefit. His examination of the relative merits of horizontal and vertical retorts with continuous feed is thorough and exhaustive, while the remarks on steaming of the coal charge and the economy of pursuing the practice embody many of the results of his own investigation. Similarly, his acquaintance with the Saltley gas works, where the apparatus possesses some unique features, enables him to supply very accurate information in the use of horizontal coke ovens. The arrangement apparently gives satisfaction, though we hear of no further installation since 1913. This hesitation may be due to the fact that the economical success of ovens is dependent on a special price for furnace coke, an uncertain factor. An instructive table is given in which the author indicates his opinion of the relative merits of different systems of carbonising. He assigns numerals in the order 1, 2, 3, to each of 18 desirable features that any system ought to possess. Among these features are low capital charges, low maintenance cost, yields of gas, freedom from naphthalene, ease of management, &c. As the figures of merit are in descending order, the smallest total represents the highest efficiency, supposing equal weight to be given to each of the elements of the table. Six different systems have been under investigation, and it would be interesting to know how far the authors' judgment is approved by other competent authorities. We give the six classes in order of merit judged by the minimum total. The list is headed by "Continuous Verticals," followed by Continuous Intermittent Verticals. Two classes, nearly equal, of lower order are "Modern Horizontals with Stoking Machinery" and "Coke and Chamber Ovens." "Intermittent Verticals," and *longo intervallo* "Inclines" close the list. It is not surprising that inclines come out at the bottom, for when writing of inclined setting, the opinion is expressed, that few engineers would now think of installing these, and others would be glad to see the last of them. The trouble with naphthalene which has been so great a bugbear in the past, that its freedom from production acquired a place in the 18 points, seems to have been amenable to judicious treatment, for another table shows that while the number of complaints in 1904 was 16,646, and rose in the following year to 22,748, dropped in 1906 to 530, and in 1908 to 46.

Chapters follow on condensing, washing, and purification, and in these, as in dealing with all practical matters, the author is seen at his best. It may be noted, that while all the older designs for condensing were built with the view of slow process, the more modern rapid cooling plant has not been able to displace them. New machinery is designed to carry out either slow or rapid cooling, at the option of the purchaser. Individual judgment is entitled to full play, for it is doubtful if any system, is quite immune from "stopped pipes." Of washers the author can speak with less ambiguity, for the centrifugal class excels, by virtue of its small size and the high degree of turbulence it imparts to both gas and washing medium. The theory and practice of purification are quite well explained and thoroughly discussed. A method is mentioned that promises well, but has not yet been sufficiently tried. It consists in passing the gas through a small bed of oxide of iron, specially treated to make the oxide act catalytically, inducing the partial oxidation of the sulphuretted hydrogen to sulphur and water. It is claimed for this process that the sale of the recovered sulphur will more than repay the expense of the operation.

A long chapter is given on the distribution of gas supply, in which a number of applications are discussed, necessarily superficially. The use of steel reinforced pipes, though they are used for gas mains is a subject rather remote from the main purpose of the book. The manufacture of gas mantles has no connection with that of gas. Photometry, geysers, cookers, may all be interesting subjects, but might have been omitted, and one would scarcely go to a book of this character to study the principles of internal combustion engines. It would be unfortunate if the miscellaneous contents of this chapter prejudiced anyone against the better qualities and many merits of the work.

Early Science in Oxford. Parts III and IV. *Physics and Surveying.* By R. T. GUNTHER. Printed for the Author. Oxford University Press. 1923. [Price 21s.]

A CHORUS of disapproval is raised whenever necessary restoration or inevitable extension demands the removal of some specimen of ancient domestic architecture from the streets of Oxford. To diminish the charm and to obliterate some of the variety of tone, that has given distinction to the city throughout the ages, is regarded as an offence to public taste and culture. Those who shake their heads despairingly over the renewals, may remember that the work of reconstruction has been continuous, and doubtless the same bemoaning will be heard, when the modern buildings of to-day are in their turn replaced by others. But the same outcry is not heard over the disappearance of those equally irreplaceable relics of the past, in which can be read the history of science. Much has been allowed to decay and perish for want of appreciation and lack of discernment. As mechanical construction improved and less cumbrous instruments were devised, the old suffered by comparison and have perished ignominiously. The effect has been that we have lost much that would have taught us the process by which the scientific idea grew and assumed the form and power it now has. The instruments, the documents of themselves may be of no great value, but the indications they afford of the process by which the infantile beginnings grew to the fruitful results we enjoy to-day are priceless. We shall never learn how men became convinced that order, discoverable order, and inevitable law, controlled the world, but something might have been gained from the study of the scientific movement at a critical epoch in its history, the period separating Roger Bacon from Sir Henry Savile.

It were well that some attempt should be made to prevent further loss and to make available such relics as remain, and therefore we welcome the effort of Mr. Gunther of Magdalen College to collect what relics still exist, to catalogue them, to place them as far as possible beyond the chance of destruction, and possibly to attract the attention of others, who are in possession of old instruments with the view of ensuring their due preservation. The care bestowed on early printed books has been far greater than that shown to instruments, and the mass extant is proportionately greater. The ease with which books are preserved in libraries, and their small size, have been favourable factors, but instruments are unfortunate, in that they require space for storage, and by their cumbrous form have had to give way to objects more attractive. Whether this be the reason or not, Mr. Gunther informs us that the first specimens of the air pump, the microscope, barometer, hygrometer or of the first electric battery, neither in Oxford nor out of it, are there any examples to show. Notwithstanding that Wren, Hooke and Boyle seem to have had a hand in every scientific invention in this country, no scrap of their work is now extant.

Mr. Gunther prefaces this section of his work by some remarks on the teaching of natural philosophy in the eighteenth century, reminding us of many honoured names, but not adding greatly to our knowledge of the science of the period. Chapters follow devoted to descriptions of clocks, barometers, microscopes and of instruments used in meteorology and in surveying. Other chapters relate to the state of knowledge of hydrostatics, sound, light, heat, electricity and magnetism. The outlook is wide and the arrangement should be satisfactory, but proves a little disappointing. Perhaps the attention is allowed to wander too freely, and more concentration on salient points is needed. The instruments rather than the purpose of each scientist is emphasised. In his desire to be exhaustive too many instruments or curiosities have been included. Some exhibit no technical or mechanical action, such as the fusion of iron nails by lightning, or are so modern in their construction that similar articles can be purchased of any optician. Interest is frittered away in the examination of trifles. In his anxiety to exhibit the whole of his stock our guide hurries us away too rapidly from object to object. The author is to be congratulated on successfully unearthing the oldest Oxford microscopes, dismantled and grey with the dust of ages, in a cupboard at Christ Church. They are declared to be of surpassing value, and we would have liked to have learnt how they differed from others of the same period and from modern specimens, but the great number of objects mentioned does not permit an adequate description.

Similarly with the men who figure as makers and designers of instruments. We could willingly have lingered in their company much longer, had our guide revealed more fully the practical details of their work and shown how the knowledge of tools had assisted, or the want of them limited, the aims of the workers. The degree of technical skill they had acquired is not illustrated, and a great opportunity has not been fully utilised.

Hooke, Boyle and Wren are the chief actors in this scientific drama, and the reputation of these protagonists gains by the collection of so much of their work into a narrow compass. Of the first of these, Hooke will long remain in engineering memory by reason of the mechanical contrivance known as "Hooke's joint," though this is by no means his chief achievement. To his contemporaries he was known as "a person of prodigious inventive head and of great vertue and goodness." He has since been described, and probably rightly, as "the greatest mechanic in his day in the world," and it is doubtful if justice has been done him. His diligence was as great as his imagination was vivid, and it is hard to overrate his versatility and power of invention. A man who proposed to deliver a

CABLE-LAYING FOR THE MORWELL POWER SCHEME.

THE TRANSMISSION SYSTEM OF THE MORWELL POWER SCHEME.

PROGRESS is being made with the Morwell Power Scheme in Victoria, and we have received some notes on the laying of the underground transmission system adopted in the immediate neighbourhood of Melbourne. As a first stage some 50 miles of three-core paper insulated lead-covered armoured cable, having a section of 0·15 sq. in. per core, and intended for distribution to sub-stations at a working pressure of 22,000 volts, are being laid. Over 35 miles have already been placed in position and tested.

The cables laid run from the auxiliary power station at Newport to the terminal house at Yarraville, a distance of about 2 miles. For more than half of this the trench, which is 7 ft. wide, is cut through solid rock, and is in places as much as 12 ft. deep. From Yarraville three cables run to the Melbourne City Council's sub-station at Spencer-street, and two others to Ascot and Royal Park. These distances are between 4 and 5 miles in a direct line, the actual route followed being a good deal longer. All five cables are carried across the Maribyrnong River at Footscray, whence for 2 miles they run over the West Melbourne Marshes on an embankment to the Coal Canal Lagoon. The accompanying illustration shows the method adopted in connection with the crossing of the latter. A line of barrels and rafts was placed across the canal, and rollers fitted, over which the submarine lengths were hauled by power-winding gear. At the shore ends rollers placed on timbers laid across the trenches facilitated operations. The work was expeditiously carried out, the crossing being completed in one day. A similar method was employed at the crossing of the Maribyrnong River.

The whole of the 50 miles of 22,000-volt cable was manufactured by Messrs. Siemens Brothers and Co., Limited, at their works at Woolwich, and the laying, jointing and testing were supervised also by them. The cables were tested to 50,000 volts alternating current at the makers works, and to 44,000 volts alternating current after laying and jointing.

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weekly discourse to the Royal Society and to illustrate these by one or two experiments, was of no common order. The violence of his temper and the attitude he assumed towards Newton and Halley have placed him in an unfavourable light, the more readily received and perpetuated on account of Biot's bitter epitaph: "Hooke est mort: c'était un homme de génie, et un mauvais homme: la Société y gagne plus que la géometrie n'y perd." In the volume under notice, the author has done nothing to remove the veil that obscures Hooke's merits or hides his defects.

Hooke had been in Boyle's service, and it is impossible to determine now how far the latter benefited by Hooke's genius or the nature of the tie between them. Boyle, however, parted from Hooke reluctantly, and the disinterestedness of Boyle was considered so great that the Royal Society passed a vote of thanks to him for releasing Hooke from his service and allowing him to enter that of the Society. Unfortunately, no part of Boyle's apparatus, whether of his own work or made in conjunction with Hooke, has survived, but his reputation is as deserved as it is well known. Wren's work and reputation as an architect have overshadowed the position he acquired by his many mechanical applications and his acute reasoning from experiment. His work on clocks, on navigation, on meteorology, are well treated here. Perhaps the most notable is the contrivance of a self-registering thermometer and an automatic wind-recorder, whereby an observer "by the traces of the pencil on the paper, may certainly know what winds have blown during his sleep, or absence, for 12 hours together." The machine has been the forerunner of many useful applications of automatic registration. We are grateful to Mr. Gunther for calling attention to the work of this all-round genius, and for driving home the lesson to be learnt from the records of these giants, that other men have laboured and we have entered into their labours.

THE NEW YEAR HONOURS.—The list of honours intimated in the *London Gazette* at the incoming of the year shows the long-established characteristic of the almost entire absence of the names of members of the engineering profession. Shipowners are represented by the elevation of Lord Inchcape to a Viscounty and by the inclusion of Major Herbert R. Cayzer, of the Clan Line, in the list of Baronets. Knighthoods have been conferred on Mr. Arthur Watson, the general manager of the London, Midland and Scottish Railway, and on Mr. Thomas H. Mottram, H.M. Chief Inspector of Mines, while Engineer Vice-Admiral Robert B. Dixon, the Engineer-in-Chief to the Navy, has been promoted from C.B. to K.C.B. Eng. Capt. F. E. P. Haigh is made C.B.

GERMAN TRADE IN ARGENTINA.—Judging by the manifests of numerous vessels arriving from Hamburg and Bremen, German trade in the Argentine Republic is showing steady expansion in almost all directions, says the London and River Plate Bank, Limited. Eighteen such arrivals were noted in October, and the cargoes included iron and steel, wire of various sorts, cotton prints, glass and earthenware, photographic material, wood-working machinery, tiles, bentwood furniture, Osram lamps, buttons and dress accessories, rubber goods and surgical instruments, musical instruments, and bazaar goods of every possible variety. It is to be remembered that in all likelihood much is transit cargo from other Central European States, but even so the widespread connections of the German merchants in Argentina are interestingly demonstrated by the remarkable variety of the goods which they now have coming to hand with remarkable regularity.

AN ACCOUNT OF AN EXAMINATION OF THE MENAI SUSPENSION BRIDGE.*

By HENRY TUDSBERY TUDSBERY, M.C., M.Inst.C.E., and ALEC ROBERT GIBBS, Assoc.M.Inst.C.E.

THE Minister of Transport having asked for a memorandum dealing with the question of the safety of the Menai suspension bridge, the Director-General of Roads gave instructions that a complete examination of the bridge should be made and a report submitted thereon. The national importance of the Menai bridge and its historical associations render it of special interest to members of the Institution; whilst the question of the methods to be adopted in investigating the suitability of old structures for modern conditions of traffic affords matter for serious consideration.

Description of the Bridge.—The bridge was designed and built by Thomas Telford in 1820–26, and is still the only road-connection between Anglesey and the mainland. The suspended span, which is 580 ft. from centre to centre of the towers, is supported by four main chains, which divide the bridge into two roadways and a centre footway. Each of the four main chains consist of four lesser chains superimposed, and each single chain is composed of five long links and six short links alternately the links being connected by 3 in. diameter forged unturned pins. The platform is suspended from the chains by 1-in. square rods hung vertically and attached to cross girders, which in turn carry the longitudinal trough flooring. The floor as now existing weighs about 320 tons more than the original floor.

Method of Examination.—The general procedure adopted in the examination of the bridge was as follows: (*a*) Collection of information available from drawings, &c.; (*b*) verification of this information and collection of further information from the site; (*c*) theoretical calculations; (*d*) detailed examination of all parts of the bridge; (*e*) extensometer measurements of existing stresses; (*f*) tests to ascertain the stresses produced by live load and impact therefrom on the various members of the bridge; (*g*) physical tests to ascertain the nature and present condition of the wrought iron.

The bridge is built of forged members made up of welded wrought iron, which, therefore, vary considerably from the nominal sizes. It was consequently necessary to ascertain the minimum dimensions of the existing links in the main chains and the exact condition of the individual members of the bridge as regards corrosion, &c.

The choice of a suitable extensometer was not an easy matter. Although the examination had been delayed until the summer to get fair weather conditions, the wind sometimes attained a speed of 40 m.p.h. When arrangements had been made for the removal of the links or for the attendance of test loads, &c., it was imperative, for financial reasons, to proceed according to programme, and consequently necessary to have instruments which were capable of use under unfavourable conditions and in exposed positions. Permission was therefore obtained of the Minister to use a stress-indicator designed by one of the authors, which appeared likely to be suitable. This instrument proved equal to all the requirements; it was simple, could be used in a confined space, was not affected by a breeze, and in windy or stormy weather was easily protected by a tarpaulin hung on the windward side.

Three complete groups of links were removed from the main chains (*a*) near the centre of the span, (*b*) near the Anglesey tower, (*c*) over the Anglesey approach. Extensometer tests were made during both the removal of the old links and the insertion of the new links, and the stress in each link, and the total load on each group of links, were observed.

The chains in the tunnel were generally in good condition, but a number of badly-corroded links, both long and short, were found in the chains in the open. This condition was obviously not anticipated by Telford, as he increased the section of the chains in the tunnels by 85 per cent. to allow for loss by corrosion. The chains in the tunnel have been painted by direct labour, whilst the chains in the open have been painted by contract. The authors are of the opinion that in this case the former method is the more satisfactory, but that it is not possible entirely to arrest corrosion of the nature existing in parts of the bridge, and painting can only be considered a palliative.

The saddles are supported by turned expansion rollers, which are corroded to such an extent that they do not act in a satisfactory manner, the movement of the saddles over the rollers being only a fraction of the calculated figure. The authors point out that the absence of means of preserving the rollers from corrosion was a weak spot in early designs. It was found from observations that the dead-load stresses are transmitted to the approach chains, but the failure of the rollers to operate prevents any live-load stresses from being carried to the chains over the approaches, and must consequently induce considerable stresses in the masonry towers. Observations with stress indicators show that the stresses in a group of five bars forming one link may vary by 70 per cent., and are not uniform, as would be assumed in theoretical calculations. The authors consider that this is due to errors of workmanship in the forging of the pins, which were not turned. When new pins were inserted, a much better distribution of stress was obtained. Observations were made of the additional stress induced in the chain by the operation of removing and replacing links.

The live-load tests generally confirmed theoretical computations, the impact from traffic proceeding in accordance with the regulations (walking pace) or from a lorry bumping over a 2-in. piece of timber being very small so far as the main chains were concerned. The authors

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* Abstract of a paper to be read before the Institution of Civil Engineers, on January 8, 1924.

summarise the stresses to which the main chains are subjected, and in this connection the following loads have been taken into account: (*a*) Dead load of structure: (*b*) live load coming on the bridge; (*c*) impact from live load striking obstructions (this has not been added to the total).

Loads rendered necessary by repairs to the bridge as follows: (*d*) Load induced by dead weight of stopper. (The stopper is the appliance used for holding the ends of the links of the chains while intervening links are removed and replaced.); (*e*) additional stress induced in chain, when the stopper is tightened up.

The following are the maximum recorded stresses, taking no account of stresses set up by wind, &c.:—

Centre of Bridge.	Near Tower.	Anglesey Approach.
Tons per sq. in.	tons per sq. in.	tons per sq. in.
(*a*) 7·2	(*a*) 8·18	(*a*) 8·58
(*b*) 0·73	(*b*) 0·63	(*b*) nil
(*c*) Not added	(*c*) Not added	(*c*) nil
Total (*a*) and (*b*) 7·93	8·81	8·58
(*d*) 0·30	(*d*) 0·30	(*d*) 0·30
(*e*) 1·36	(*e*) 1·50	(*e*) 1·43
Total ..9·59	10·61	10·31

The recorded stresses show some variation from those calculated, as they show the effect of stresses induced by irregularities of workmanship, such as unturned pins, irregular lengths of links, &c., also the possibility that the load is not evenly divided between the four chains forming one main chain.

The stresses in the bridge are unusually high, and the factor of safety to be considered a minimum is a debatable point. The usual factor of safety for a structure of this nature, ignoring wind stresses, would be one-fourth of the ultimate stress or one-half of the elastic limit. Under the actual conditions it is found that in places the wrought iron is at times stressed to its elastic limit. It has to be remembered that the members of the bridge are made up throughout of welded parts, the individual bars which form the long or short lengths of the main chains having been made of piled rods; the eyes also were forged separately and then welded to the shanks. The suspenders were similarly welded.

Tests made at the National Physical Laboratory on links removed from the main chains gave a yield stress of 13·6 tons to 16·2 tons per square inch and breaking loads of 19·8 tons to 24·5 tons per square inch. The tests made to ascertain the limit of proportionality gave a mean of 10 tons per square inch. The more important results of tests carried out by the National Physical Laboratory on 11 long links removed from the bridge are given in an appendix, with certain collated results of tests carried out on the site.

There are 796 suspenders or vertical ties in the bridge, and each of these comprises from two to six lengths. Those over the approaches only serve the purpose of maintaining the chain in the desired curve. These bars nevertheless carry a load approximately equal to the dead load in similar ties on the suspended span, and therefore cannot be ignored.

In 1908 considerable renewal work to the bridge was carried out, the renewal of vertical ties being an important part of this work. No seriously-corroded bars, therefore, were discovered on the present examination; and, where a bar was noticeably corroded, it was found to have been originally of larger size than normal. In all cases these corroded bars are situated in the approaches and are not liable to live load, but they are, of course, liable to variation in stress due to wind pressure.

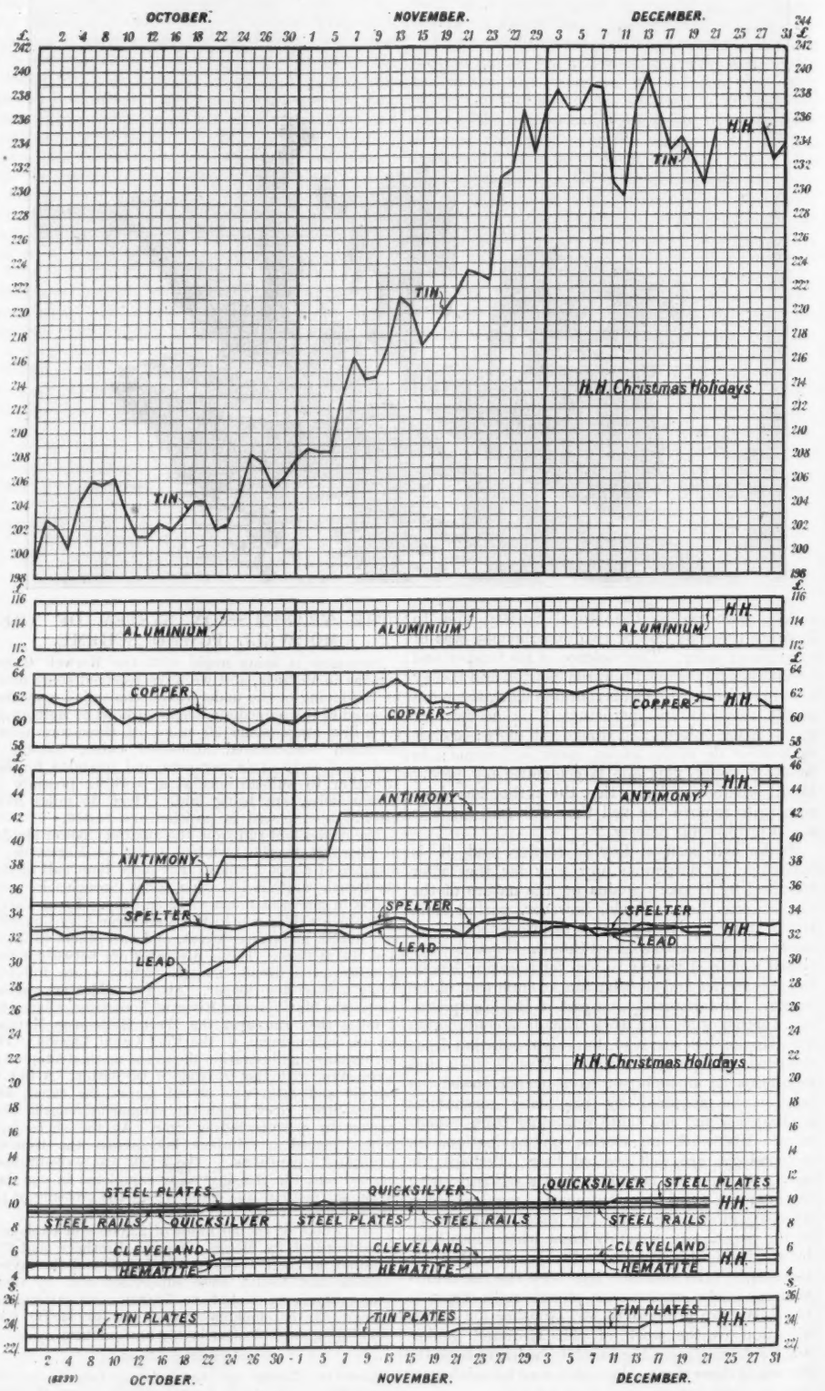
Experience with stress-indicators on the suspension rods illustrated how difficult it was to estimate the load they were carrying by vibrating them. There is considerable variation in the tautness of the rods, and they might with advantage be adjusted by means of instruments similar to those used during the examination. When the stress indicator was in use on these bars during July it showed on many occasions an increase of stress of about 1 ton per square inch due to the wind. In considering the calculated loads coming on these rods, the vibration due to wind has to be taken into account. Although exact details as to the quantity of traffic passing over the bridge are not available, it may be taken that approximately 2,000 tons passes over the bridge daily during the summer months.

COAL DEPOSITS IN HOLLAND.—The Dutch Government has for a considerable time made borings for coal at Winterswyck, in Gelderland, in the vicinity of the Westphalian frontier. The borings have now reached a depth of 1,287 metres and in addition to the good coal deposits previously discovered, a bed of 1·70 metres has now been reached. The coal is best quality industrial coal. Altogether seven coal deposits have been discovered, their quality being quite equal to best Westphalian coal. Besides coal, a deposit of mineral salt of very large promise has been located.

THE INDUSTRIAL LEAGUE AND COUNCIL.—A series of lectures on "Management and Industry" will be given in the Fyvie Hall of the Polytechnic in the evenings at 8 o'clock of the following dates:—January 11, Motion Study and Fatigue Study: The Fundamentals of Economic Production, Mr. James F. Butterworth; February 8, The Safeguarding of Health in Industry, Dr. Edgar L. Collis; February 22, The Economic Aspect of Cost Accountancy, Mr. H. W. Allingham; March 7, The Attitude of Labour to Problems of Industrial Organisation, Mr. F. S. Button, J.P.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of quicksilver is per bottle, the contents of which vary from 70 lbs. to 80 lbs. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

CRANK SHAPING MACHINE.

CONSTRUCTED BY MESSRS. SCOTT BROTHERS (KEIGHLEY), ENGINEERS, KEIGHLEY.

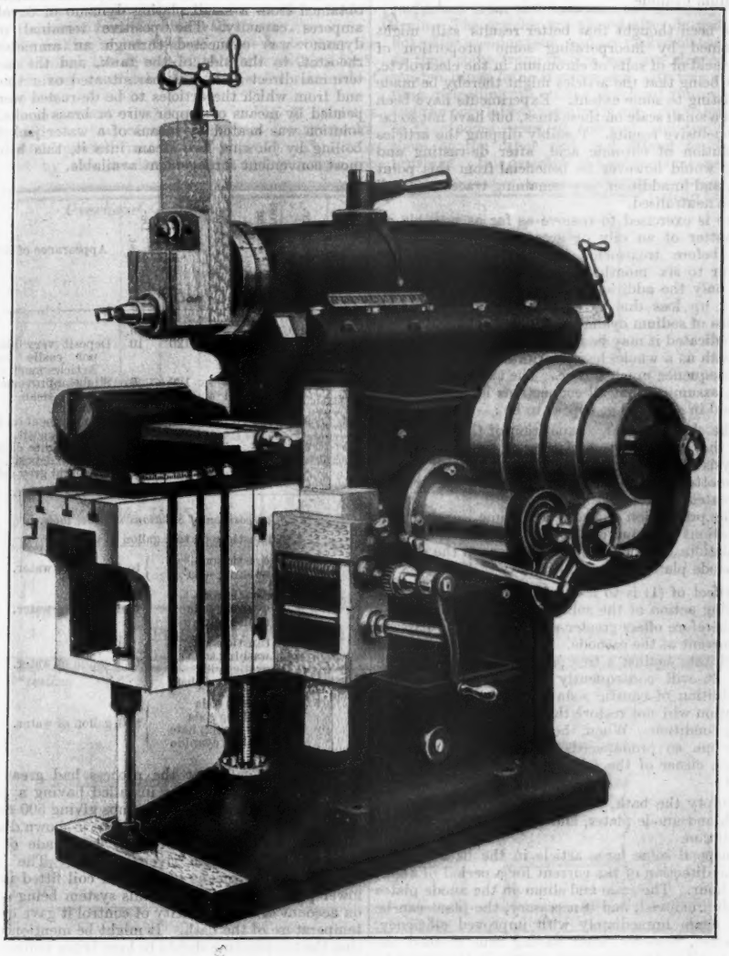
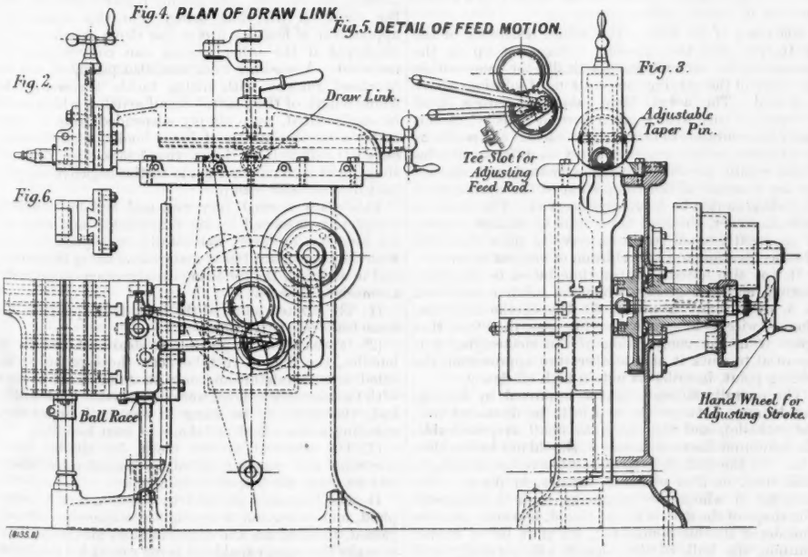


FIG. 1.



THE illustrations on this page, Figs. 1 to 6, show the construction of a new design of crank shaping machine manufactured by Messrs. Scott Brothers (Keighley), of Albion Works, Keighley. In this model many interesting features have been introduced to obtain efficient operation in the special field of service to which a shaping machine may be economically applied. In Fig. 1 is given a pictorial view of the general arrangement of one of the largest sizes, while the details, which are similar in the complete range of sizes, are shown in Figs. 2 to 6.

The machine is built upon a combined base and column. As the base is of the extended type and is large, effective support is given to the machine, and rigidity is ensured by the use of internal ribs in both base and column. A bearing of exceptional length is provided for the ram by the projection of the top of the column to the front and back. The ram is of the Vee type, which has the advantage that the ram may be held down with little friction and with freedom from vibration. It is claimed that with this type of construction the wear is regular and that easy adjustment may be made for it. The adjustable keeps are two loose Vee strips made from hard close-grained metal which are accurately machined and scraped. The drive for the ram is carried through from the three or four-coned pulley to the internal gear wheel (see Figs. 2 and 3) and thence by means of a slide in the rocker arm to a double draw link pinned to the ram. As the rocker arm is not attached directly to the ram the tendency to lift it during half of the cutting stroke is avoided. Actually the pull on the ram in this machine is downwards throughout the cutting stroke and thus neutralises some part of the upward thrust of the tool. It should also be noted that the rocker arm is mounted on a pivot shaft at the foot of the column which supports its weight. The length of stroke may be varied at will, without stopping the machine, and a pointer on the ram travelling over a scale shows the length of stroke obtained by the setting. The head is operative at any angle within an arc of 180 deg., and is provided with a convenient locking device. The down feed is of unusual length and a large tool post is supplied to accommodate holders with inserted tools.

The cross rail is of box form and gives the possibility of extended horizontal travel for the table. It is gripped to the column by clamps and bolts. A ball thrust bearing (see Fig. 2) is provided on the elevating screw to facilitate the raising of the rail. Extra wide bearings are introduced for the apron to ensure rigidity, and the support for the table is such that the rail is relieved of much of the load due to the weight of the table and the work, and thus the wear is reduced. The table, which is firmly fitted to the apron and held in position by bolts, is of complete box section. Rigidity of connection between the apron and table is further increased by the use of two dowel pins extending into the table. The cross feed is automatic and variable, and provides a graded range. The arrangement is clearly indicated in Figs. 1, 2 and 5. The vice is a new design with deep and wide jaws, which are steel faced. It is provided with a large clamping ring graduated in degrees, and the screw has a bearing at each end and is always in tension when holding the work.

THE REMOVAL OF RUST BY ELECTROLYTIC PROCESSES.

By Captain J. P. MCLARE, B.Sc., A.M.I.E.E., R.A.O.C.

AT the end of the late war, vast quantities of war material were left on hand, and the question arose as to the quantities and descriptions which should be preserved and retained in store for future emergencies, and to meet the requirements of the post war army, and those which should be disposed of. The general answer to the question could, of course, only be arrived at by considerations of policy, and of a study of possible and probable emergencies. Having however determined such requirements, there remained amongst others, the further question as to which articles could profitably be retained, having regard to the cost of storage and the cost and rapidity or otherwise, with which they could be replaced by new articles, if and when emergency should arise.

A vast proportion of the material under review consisted of valuable iron and steel articles, ranging from guns and howitzers to small tools and implements which from exposure to the elements, had deteriorated through rusting, and it was recognised that if some cheap process of reconditioning them could be evolved an enormous saving would be effected, as they could then be preserved for possible future use, or if found necessary to dispose of them later, they would have enhanced value.

With the object of devising some such process, experiments were carried out in the R.A.O.C. workshops at Chilwell. The requirements were :—

(1) That all rust should be completely removed. Any remaining rust, even though slight, would be conducive to further rusting taking place, even though the articles were painted or otherwise covered with a protective coating.

(2) That the process should remove rust only, and not affect the sound metal.

(3) That the physical properties of the iron and steel should not be affected.

(4) That the process should be cheap, and capable

of dealing rapidly with large quantities of widely ranging descriptions of articles.

No method of hand scraping and cleaning could properly meet those requirements, and any semi-mechanical process such as buffing or scratch brushing, would be comparatively slow and would entail a great deal of labour, besides being only partially effective. For very small articles, the well-known expedient of "rumbling" could no doubt, be usefully employed, but only a very small proportion of the articles under consideration come within the scope of this method. Attention was therefore directed towards the development of the chemical and electrolytic methods which had been used in the base workshops of the R.A.O.C. during the war, for cleaning articles preparatory to the process of electro-deposition. The first process which was tried out during 1919 and 1920 was as follows :—

(*a*) Articles were swilled in a boiling solution of caustic soda for a few minutes.

(*b*) Washed in boiling water to remove caustic soda.

(*c*) Placed as anodes in an electrolytic bath, containing a solution of 10 per cent. commercial concentrated sulphuric acid, and 90 per cent. water; the cathodes being zinc plates. A current provided by a 60-ampere generator was passed, under a pressure of from 6 volts to 10 volts, for about 20 minutes. This removed or loosened the rust.

(*d*) Articles were then washed in hot water to remove the acid, and were scrubbed with scratch brushes.

(*e*) Dipped in boiled linseed oil or other suitable preservative.

This process proved to be not altogether satisfactory, chiefly for the following reasons :—

(1) A good deal of the rust was merely loosened, and a great deal of scrubbing was necessary afterwards to obtain a clean surface.

(2) The solution attacked the sound metal more readily than it did the rust.

(3) Traces of the acid were left in the pores of the metal, and further corrosion soon took place.

(4) The electrolyte required constant renewal.

It was decided, therefore, to experiment with an alkaline electrolyte in place of the acid, and various solutions were tried, the chief constituents being caustic soda and sodium carbonate. In this case, the bath was worked at a temperature approaching boiling point, and had the advantage over the acid process in that it eliminated the necessity for any preliminary dipping in caustic soda with the subsequent washing which this entailed.

In the case of the acid bath it will be noted that the article formed the anode, and the rust was removed partly by being directly attacked by the electrolytic action, and partly by the basis metal being attacked and loosening the rust clinging to it. In the caustic bath, however, the article was made the cathode, and it was found that the violent evolution of hydrogen which ensued when a heavy current was passed, had the effect of bringing about the reduction of the rust, the oxygen of the latter combining with the hydrogen to form water, while the iron content was left on the article in the form of a black powdery deposit.

The action of this bath was found to be much more rapid and effective than in the case of the acid bath. The articles dry quickly on removal, and the powdery deposit of iron can be removed comparatively easily by washing and scrubbing, leaving a dark grey-coloured surface. If it is desired to obtain a perfectly clean metallic surface, the articles can be put into an acid bath similar to that already described, and in two or three minutes, with a current density of about 170 amperes per square foot, all remaining film of loose iron will be removed.

Composition of Alkaline Bath.—The actual composition of the electrolyte for this bath can vary widely and yet give almost equally satisfactory results. The general requirements are that it should be a concentrated solution, strongly alkaline, and contain such salts in addition, as will assist in producing a vigorous evolution of hydrogen at the cathode for the purpose of reducing and throwing off the rust, and form other products which also chemically attack the rust.

Caustic soda provides the alkaline base, with washing soda (sodium carbonate) as an addition to improve the conductivity; and sodium cyanide and sodium sulphate the other ingredients. The presence of the cyanide has the effect of removing a good deal of the black deposit of reduced iron, and the article comes from the bath much cleaner in appearance, and with much less matter to be subsequently removed by washing and scrubbing. Oxalic acid may be used as an alternative, to bring about this cleaning effect, but the cyanide is to be preferred as it appears to be more efficient in this respect, and a much smaller quantity of it is required.

For general purposes, an electrolyte of the following composition has been used with very satisfactory results :—

	Per Gallon of Water.
Commercial caustic soda	¾ lb.
Washing soda	¾ lb.
Salt cake (sodium sulphate)	¼ lb.
Sodium cyanide	1 oz.

It has been thought that better results still might be obtained by incorporating some proportion of chromic acid or of salts of chromium in the electrolyte, the idea being that the articles might thereby be made rust-resisting to some extent. Experiments have been made on a small scale on these lines, but have not so far given conclusive results. Possibly dipping the articles in a solution of chromic acid, after de-rusting and washing, would however be beneficial from this point of view, and in addition, any remaining traces of alkali would be neutralised.

If care is exercised to remove as far as possible all loose matter of an oily or greasy nature, from the articles before treatment, the electrolyte will last from four to six months of continuous working, requiring only the addition of water from time to time, to make up loss due to evaporation, and of small quantities of sodium cyanide. Towards the end of the period indicated it may be found that the conductivity of the bath as a whole, has deteriorated and its action is in consequence much slower. The two main reasons for this, assuming that all connections have been kept sound and in good order, appear to be :—

(1) The change in the composition of the electrolyte due to the gradual accumulation of products of the electrolysis and of the reaction between the alkali and greasy matter introduced into the bath by the articles being treated.

(2) The production of a scale and slime, consisting of precipitations of iron oxides and sulphates, and of accumulations of other insoluble matter, on the surface of the anode plates.

The effect of (1) is to lessen the penetrating or disintegrating action of the solution on the layer of rust which therefore offers greater resistance to the passage of the current at the cathode. Similarly, the scale and slime militate against a free passage of current at the anode. It will consequently be realised that the mere addition of caustic soda or other substances to the solution will not restore the bath to a satisfactory working condition. When, therefore, the deterioration has become so pronounced as to call for remedial measures, either of the following procedures may be adopted :—

(*a*) Empty the bath, thoroughly clean the inside of the tank and anode plates, and refill with a completely fresh solution.

(*b*) Suspend some large article in the bath and reverse the direction of the current for a period of about half an hour. The scale and slime on the anode plates is thereby removed, and if necessary, the plant can be worked again immediately with improved efficiency. It is better, however, after having thus cleaned the plates, to allow the suspended matter in the liquid to settle, and then to remove the sludge from the bottom of the tank, making up the wastage by adding a strong solution of caustic soda.

Efficiency of the Bath.—The actual resistance of the electrolyte, and the opposing voltage set up on the passage of the current, are practically the same within the range of the varying compositions of solutions above indicated. The actual time taken to reduce equal amounts of rust with a given current density, cannot easily be accurately determined for various compositions of solutions, as the amount of rust on different articles is not readily capable of being estimated, and also the precise moment of the completion of the operation of de-rusting cannot be definitely observed. The annexed table, however, obtained from tests on similar articles, of apparently equal rustiness, serve to show the effect of concentration and the addition of various salts.

It was also noted that the time taken to effect de-rusting increased greatly when the solution was used at a lower temperature, at 60 deg. C. the time was almost twice as long. It would appear, therefore, that apart from the composition of the electrolyte, it is essential to work it at a temperature approaching the boiling point, in order to obtain high efficiency.

The overall efficiency can be improved by keeping the distance between the article to be de-rusted (*i.e.*, the cathode), and the anode, as small as practicable, the minimum distance, however, should not be less than 6 in. To this end, it is advantageous to use adjustable mild steel, or iron plates as anodes, in place of the material of which the containing tank is composed. The shape of the article to be treated, however, must be considered in this connection, for if it be of uneven contour, the bulk of the current will naturally tend to pass between the shorter distances between projecting portions and the anodes, to the detriment of recessed portions which are at a greater distance. A more even distribution of the current is effected in such cases by having the anodes and the articles fairly wide apart.

Description of Plant and Its Development.—The first experiments with the alkaline electrolyte were made on a very small scale; the solutions being contained in a 20-gallon, sheet iron tank, while the current was obtained from a small plating dynamo of 6 volts, 20 amperes capacity. The positive terminal of the dynamo was connected through an ammeter and rheostat, to the side of the tank, and the negative terminal direct to a cross-bar situated over the tank, and from which the articles to be de-rusted were suspended by means of copper wire or brass hooks. The solution was heated by means of a water jacket kept boiling by blowing live steam into it, this being the most convenient arrangement available.

Solution.	Temperature.	Voltage Across Bath during Operation.	Back Voltage.	Current Density.	Time to De-Rust.	Appearance of Article.
	deg. C.				min.	
1	90	2·9	1·4	120	10	Deposit very black and not easily removed. Articles much stained.
2	90	2·8	1·4	120	9	Slight improvement on 1.
3	90	2·8	1·4	120	7	Fairly clean. Less stained.
4	90	2·7	1·4	120	5	Improvement on 3. Very little deposit.
5	90	2·7	1·4	120	3	Almost quite clean, only slight deposit. Metal natural grey colour.

Composition of Solutions in above table.

1. ¾ lb. caustic soda to 1 gallon of water.
2. ¾ lb. caustic soda, ¾ lb. washing soda } to 1 gallon of water.
3. ¾ lb. caustic soda, ¼ lb. washing soda, ¼ lb. oxalic acid } to 1 gallon of water.
4. ¾ lb. caustic soda, ¼ lb. washing soda, ¼ lb. oxalic acid, ¼ lb. sodium sulphate } to 1 gallon of water.
5. ¾ lb. caustic soda, ¼ lb. washing soda, ¼ lb. sodium sulphate, 1 oz. sodium cyanide } to 1 gallon of water.

Having decided that the process had great possibilities, a small plant was installed having a tank of 300 gallons capacity with dynamos giving 500 amperes at 6 volts. The lay-out of this plant is shown diagrammatically in Fig. 1. The tank was made of ¼ in. mild steel plate, with riveted joints. The heating was effected by means of a steam coil fitted into the lower portion of the tank; this system being adopted on account of the simplicity of control it gave over the temperature of the bath. It might be mentioned here, that the temperature should be kept below boiling-point, for if exceeded, it will be found that the ebullition is very vigorous and causes considerable wastage of liquid, flooding the vicinity, and making it impossible to work the plant for the time being. For this reason the application of heat by fire or gas stove should not be employed if the other system can conveniently be installed. A washing tank was also provided and an overhead runway with lifting tackle traversing the whole length of the plant. Small articles, which could be easily lifted, were simply suspended from a brass cathode bar by means of brass hooks, while heavier ones were slung from the overhead tackle by insulated slings, and a connection made to the negative supply lead by a suitable clamp.

This plant worked very well and articles could be completely de-rusted by its aid, quickly and cheaply. Its capacity, however, was totally inadequate to cope with the large quantities of material awaiting treatment, and in addition, the following disadvantages soon made themselves apparent :—

(1) The riveted joints of the tank developed troublesome leaks in a short time.

(2) It was found impossible to deal with articles in bundles, the film of rust between the separate items acted as an insulator, and only those in direct contact with the suspending hook were de-rusted. Each article had, therefore, to be hung in the bath separately, entailing a good deal of labour in man handling.

(3) The removal of the black deposit by hand-scrubbing and washing called for considerable labour and retarded the output of the plant.

It was therefore decided to instal a much larger plant, and endeavour in the light of experience already gained, to eliminate the disadvantages mentioned, and to make the plant capable of being run with a minimum amount of labour. A dynamo of 10 volts, 2,000 amperes capacity, was obtained, and correspondingly larger tanks made to suit. The difficulty of leakage from riveted seams was easily overcome by making welded

joints, and contact to each article was ensured by the use of special trays.

Two schemes for labour-saving in handling and washing the articles were tried :—

(*a*) By arranging a series of four tanks of similar dimensions, incorporating an acid cleaning bath, into which a tray loaded with the articles could be successively immersed from an overhead runway.

(*b*) By making a motor-driven conveyor to carry the articles through the de-rusting bath and washing tank, and installing a scratch brush lathe for removal of reduced iron.

The arrangement of (*a*) is shown in Fig. 2. Articles are loaded on a tray of convenient size for the tanks, made of expanded metal (see Fig. 3). This tray is lifted by the overhead tackle and put into the de-rusting tank, connection being made when in position between the brass supporting bars of the tray and the negative leads running along either side of the tank.

After the reduction of the rust has been effected, the tray is lifted out and moved to the next tank, which is filled with boiling water, to remove the caustic solution. About 2 minutes' washing is sufficient after which the articles are cooled down by immersing the tray in the next tank filled with cold water. When sufficiently cool, the tray is put into the acid bath in which the articles become the anode, and the black deposit is removed, the time ranging from 2 minutes to 10 minutes, depending upon the thickness of the deposit and the current density.

Finally, the tray is put back into the hot water tank, this being slightly alkaline, due to the washing of the articles when coming from the de-rusting tank, neutralizes the acid, and also warms up the articles, so that they quickly dry upon removal, and are ready for dipping or greasing as may be required. The objects in cooling down the articles before being put into the acid bath are to promote its efficient working and to prolong the "life" of the electrolyte. It is found that if the articles are put in hot a vigorous chemical action takes place, but the deposit clings to them until it is all absorbed into solution as ferrous sulphate. The sound metal is also attacked meanwhile. On the other hand, if the articles are cold and the temperature of the bath is kept low, the evolution of gas brings off the deposit more rapidly.

The conveyor system (*b*) is shown in Fig. 4. In this a double endless chain, driven by a 1-h.p. motor, through reduction gearing, carries brass bars insulated from the chains, but which make contact with the negative of the supply as they pass over the two "live" rails which are suitably shaped to dip the articles suspended from the bars into the electrolyte and out again. The articles are passed after de-rusting into a hot water washing tank, and are picked off the conveyor, as they come from thence, and are cleaned off on a scratch brush lathe if necessary. By this system, the time of loading up on the overhead runway is saved, and the only labour required is one man to load the bars as they come round at one end, and two to remove them at the other end and attend to the scratch brushing. It is desirable to have some means of varying the speed of the conveyor, to suit the degree of rustiness, of the articles being treated, for general purposes however, a speed giving 7 minutes to 8 minutes immersion in the de-rusting tank, is satisfactory.

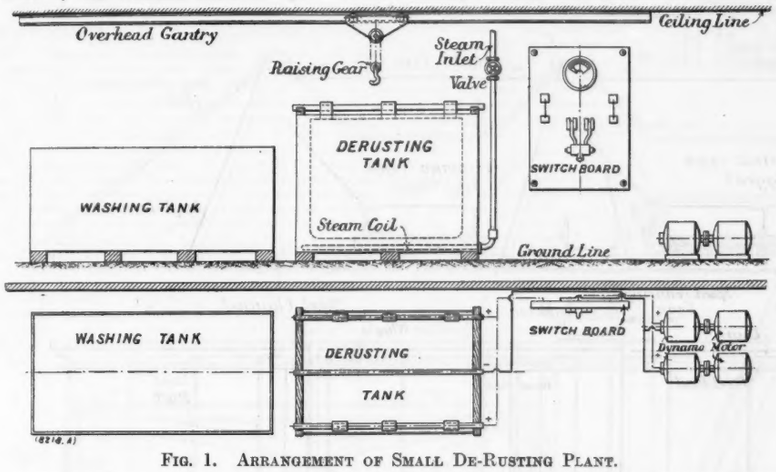


FIG. 1. ARRANGEMENT OF SMALL DE-RUSTING PLANT.

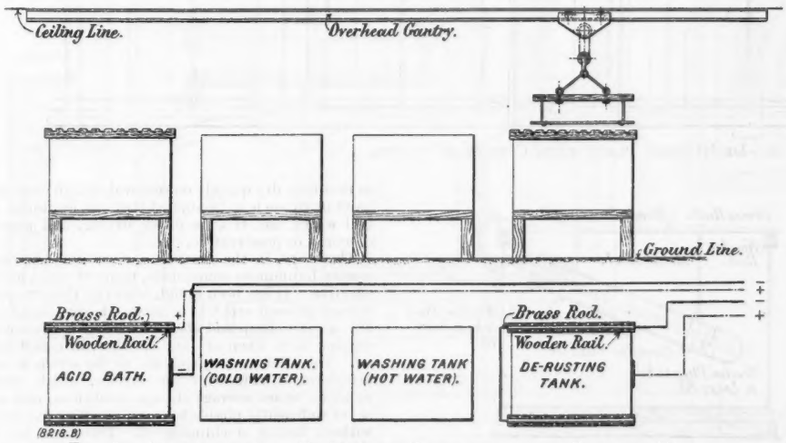


FIG. 2. ARRANGEMENT OF DE-RUSTING PLANT WITH ACID CLEANING BATH.

Of these two arrangements, the conveyor system has been found to be the better. The acid bath in (*a*) is not altogether satisfactory, as it is uncertain in its action, some of the articles in the tray being cleaned rapidly, while others are untouched. For consistent results a current density of at least 200 amperes per square foot appears to be necessary.

Current Density.—The question as to what is the most efficient current density to employ is one which requires some consideration.

Assuming for the purposes of rough analysis, that the rate of removal of rust is directly proportional to the current, and that the back voltage and resistance of the bath are constant, we can compare the output with the consumption of power as follows :—Let t be the time taken to remove a given quantity of rust with a current C, and voltage V, the back voltage being 1·4 volts. Then the power used in the period t can be represented by $V C t$. This power may be stated to be absorbed in two directions :—(1) $1{\cdot}4\ C t$ representing the energy absorbed in effecting the chemical change in the rust and in the electrolysis of the solution. The result of the transfer of this energy to the "bath" is to "charge" it, as in the case of a secondary cell.

(2) $(V - 1{\cdot}4)\ C t$, which is the power absorbed by the passage of current C through the resistance R of the bath.

If we wish to double the output, *i.e.*, to half the time t, we must double the current C. To do this, assuming R is constant, we must double the voltage $(V - 1{\cdot}4)$. The two factors of power than become :—

$$(1)\ 1{\cdot}4 \times 2C \times \tfrac{1}{2} t = 1{\cdot}4\ C t.$$

$$(2)\ 2(V - 1{\cdot}4) \times 2C \times \tfrac{1}{2} t = 2(V - 1{\cdot}4)\ C t.$$

i.e., the power represented by (1) is unaltered, while (2) is doubled. It would therefore appear that when the current C is a comparatively large one, as it is in this application, considerably more power is required to work the plant at the higher current densities.

It might be supposed that the greater evolution of gas at the higher current densities, would tend to increase the resistance of the bath, and thus put up the consumption of power even beyond that represented by the figures $2(V - 1{\cdot}4)\ C t$. Experiments, however, have shown that this is not the case, but that the resistance actually falls, and also as the back voltage of the bath takes some time to develop and rise to its maximum, the increase of power is much less than this; a test carried out on a batch of steel tent pins, all in approximately the same state of rustiness, showed that the actual increase in absorption of power by raising the current density from 40 amperes to 140 amperes per square foot, was only 10 per cent.

It has also been found that the use of higher current densities produces much better results in the cleaning of the articles, as the more violent evolution of hydrogen throws off quantities of the reduced iron, and the subsequent scrubbing required, is eliminated, or at any rate, much lessened. These considerations would appear to favour the employment of high current densities, especially when put in relation to the fact that the chief item of expenditure in running the plant is the cost of labour and not of power; on the other hand, however, the effect of the passage of heavy currents on the physical properties of the iron or steel of which the articles are composed, has to be reviewed. It is known that electrolytic action has an embrittling effect on metals due to the occlusion of hydrogen, and to an alteration in crystalline structure. It is true that this phenomenon is much less marked in the case of an alkaline electrolyte, especially when used at a high temperature, than it is in one containing an acid, at the same time, due regard must be paid to it, for the effect is intensified by the passage of a heavy current.

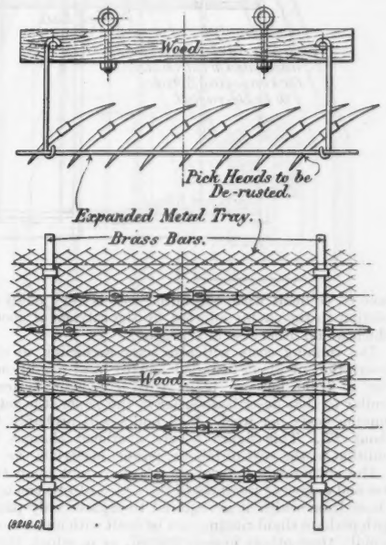


FIG. 3. TRAY FOR DE-RUSTING PLANT.

Tests were made on various pieces of mild steel, iron, cast steel, and also of brass, with a view to determining what maximum current density could safely be employed, and the following conclusions were arrived at.

Iron, mild steel and brass of any thickness over $\frac{1}{8}$ in. can be left in the bath for an hour at 200 amperes per square foot without being hardened; pieces of about $\frac{1}{16}$ in. thickness showed increases in hardness, when tested in a Brinell machine up to 10 per cent. As articles should never be required to be in the bath more than 15 minutes, a current density up to 100 amperes per square foot can safely be employed for these metals, making ample allowance for the extra current which projecting portions of an article may receive. In the

case of higher grade steel articles, and of springs, and especially those which are very thin, it is advisable to keep the current density down to about 30 amperes, and not to keep the articles in the bath for more than 5 minutes.*

Cost.—The cost of installing a complete de-rusting plant can only be given very approximately, as it will vary considerably according to the type of machinery which local circumstances may require to be put down to supply the low voltage current, the shape and size of the tanks required, the form of heating to be employed, &c. Assuming, however, that a complete motor generator be required for power and that steam heating is available, the cost would be in the neighbourhood of 15*s.* per ampere of capacity of the plant. In any case, however, where large quantities of articles have to be dealt with, the initial cost is very small in relation to the saving effected by the salvage of goods which would otherwise be scrapped.

The running costs will also vary according to the description of plant installed and to local conditions. For a 2,000 ampere plant with conveyor system, similar to that described earlier in the paper, the total running costs per week of 48 hours will probably be about 27*l.* This figure covers overhead charges in addition to the cost of labour, power, materials, &c.

The output will depend to a large extent upon the size and degree of rustiness of the articles to be treated. Those from which it is required to remove only paint with perhaps slight rusting, can be dealt with much more rapidly than others heavily rusted, or in which there are interior portions to be de-rusted. Taking, however, as a guide articles of War Department stores which have been reconditioned, *e.g.*, parts of guns and carriages, picks, shovels and tools of various descriptions, most of which had been exposed to the elements for two or three years, the weekly output from a 2,000 ampere plant should be about 6,000 articles. This gives an average cost of 1·08*d.* per article treated.

No method so far of hand or mechanical cleaning can approach this figure for cheapness, even so it is reasonable to suppose that the cost, low as it is, will be reduced as experience suggests improvements in the plant or process.

Notes on Installation and Working of Plant.—The leads from the dynamo to the tanks should be as short as possible, of ample cross section to carry the full current, and all joints and connections should be well made. This is essential in order to avoid voltage drop, as even a comparatively small drop would represent a big loss in wastage of power in dealing with such heavy currents as are used at only from 6 volts to 10 volts pressure. The prevention of heating caused by faulty or imperfect connections is a point to be carefully watched.

The dynamo should be in a separate room if possible from the rest of the plant, to avoid damage due to dampness caused by the steam from the tanks. The switchboard should be conveniently situated to the tanks, and on it should be a field rheostat for controlling the voltage, switch, circuit breaker or fuze, ammeter and voltmeter.

The de-rusting tanks should be made of mild steel plates of about $\frac{1}{16}$ in. thickness, and have welded joints, and if used as the anode, the connections from the dynamo should be made to the tank on either side, and the current distributed by having the terminals on brass plates about 10 in. square, and $\frac{1}{4}$ in. thick, bolted to the tank at those points.

It is necessary to have some form of automatic circuit breaker or fuze in the circuit, as "short circuits" may possibly occur by articles carelessly suspended, coming in contact with the sides of the tank. A reversing switch can also be incorporated in the circuit with advantage in order to clean the anode plates as required.

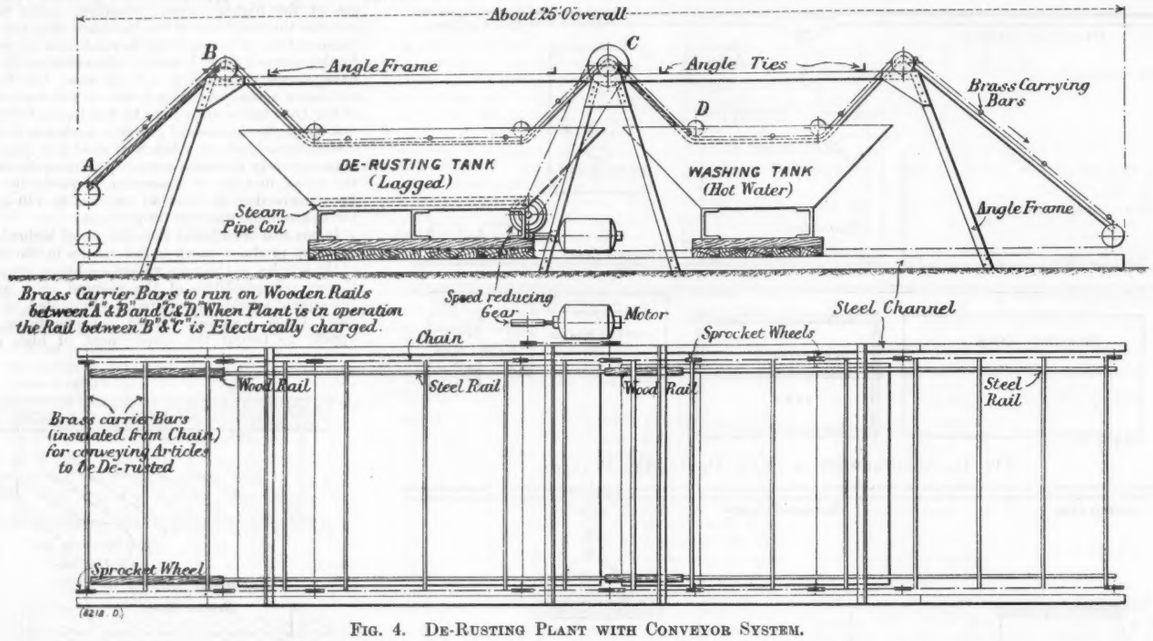


FIG. 4. DE-RUSTING PLANT WITH CONVEYOR SYSTEM.

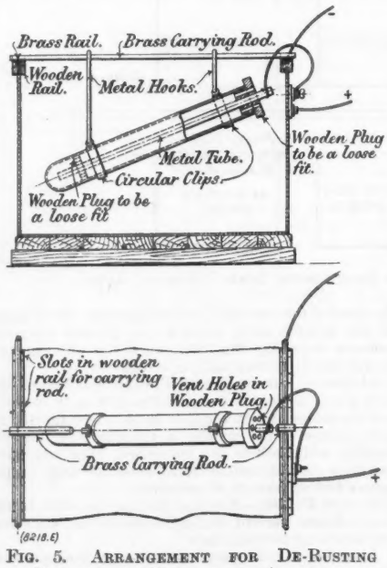


FIG. 5. ARRANGEMENT FOR DE-RUSTING INTERIOR OF CYLINDRICAL ARTICLES.

The brass hooks used for suspending the articles or trays, should be of ample thickness to carry the current and be stout enough to support the weight. A hollow article of which it is required to de-rust the interior as well as the exterior, can be treated by inserting an iron tube anode into the hollow portion. This anode can be held in position by loosely-fitting wooden blocks, the connection to it being made by a flexible lead as shown in Fig. 5.

The sludge which gradually collects at the bottom of the tank should be cleaned out every two months or thereabouts. The sides of the tank (or anode plates, if used), also become coated with a scale and slime which should be removed periodically as may be required, either by reversing the current, or by scraping.

Protection against Renewed Rusting.—The nature of the steps taken to prevent further rusting after being treated, will depend, of course, upon the type of article, and upon the treatment it is likely to receive in use or in storage. Goods to be stored in the open, or exposed in any way to climatic influences, will have to be more carefully treated than others to be left under cover. It is important, however, to remember that after the de-rusting process has been carried out, great care should be taken to ensure the washing of the articles free from alkalies, and that they should be thoroughly dry before any preservative is applied.

An immersion in boiling water effects the washing very satisfactorily, and it also warms up the articles so that they dry quickly on removal, and in cases where paint or grease is to be applied they can be dipped while still warm, and thus facilitate drying, and make for economy in preservative.

There are, in the market, various anti-rust paints, mostly bituminous compounds, many of which are very effective. It has been found, however, that for general storage of such articles, as picks, shovels, small tools, &c., a very cheap and efficient coating is produced by dipping them when dry and still hot, in boiled linseed oil. The oil dries very quickly, as the article is warm, and forms a skin over the surface, which excludes moisture under average storage conditions, and which is yet sufficiently pliable to stand handling in transport without flaking or chipping off. Petroleum jelly is a cheaper form of preservative, easily applied or removed when required, and though less efficient than linseed oil, and making the articles greasy to handle, it may be preferred in some cases.

Some articles, for the sake of appearance, may be required to be painted with ordinary paints, which alone form quite a good protective coatings. It is suggested, however, that the application of a preliminary coat of linseed oil, could often be made with advantage. One of the most efficient forms of protection against rusting, is that of electro-plating articles; and it would be a comparatively simple matter to extend a de-rusting plant to include a zinc plating bath (cold galvanising). The articles in this case, would have to pass through the acid cleaning bath, after being de-rusted, but would then be chemically clean, and after rinsing in water, would be ready for the plating bath, without further preparation. A deposition, extending over half an hour, would suffice to give a coating of zinc sufficient for ordinary purposes.

Some suggested Uses for a De-rusting Plant.—In addition to the application of this process to the reconditioning of quantities of rusted stores, as indicated in the aforegoing, the plant has been found to be very useful indeed for removing paint from metallic articles. Such removal is effected very completely in from 2 minutes to 3 minutes in this way, whereas, any method of hand scraping, burning-off, &c., entails a much lengthier operation, with a consequently much greater labour cost. Stove enamelling can also be readily removed, so that a small plant of this description, may be found to be an economical proposition, in a cycle or motor car factory. Especially if it can

* In the above, current densities are taken as being amperes per square foot of cathode surface.

be made an addition to an existing electro-plating plant.

The process can be advantageously applied, generally in cleaning articles preparatory to electro-plating, and also in the case of such processes as "Browning" and re-tinning of dirty or greasy articles, where a long boiling in caustic soda solution is otherwise necessary. In the case of very small articles, a form of "Rumbler" could be devised on similar lines to that used in barrel plating; this would effect a very rapid and thorough cleaning, and remove completely the reduced iron deposit. It is also thought that the process might be found useful in cleaning castings in foundry work, or to replace sand blasting in many instances.

OPEN HEARTH FURNACE REGENERATORS.*

By F. B. QUIGLEY, Superintendent, Open-Hearth and Bessemer Departments, Ohio Works, Carnegie Steel Company, Youngstown, Ohio.

A FURNACE in which the heat of the waste gases is used to warm the air or gas entering the furnace is either a recuperative or a regenerative furnace. In case the air or gas is warmed continuously by the waste gases, it is called a recuperative furnace. If, however, the escaping gases are used to heat brickwork, which after being heated is used to heat the entering gas or air, it is called a regenerative furnace. In other words, a regenerator is alternately heated by the escaping waste gases and cooled by the entering gas or air. In 1828, it first occurred to J. B. Neilson, to heat the blast for the blast furnace. From 1857 to 1861, at the suggestion of his brother, Frederick, Wm. Siemens applied the regenerative principle for producing a high temperature in furnaces. In the blast furnace, regeneration is not essential, but rather economical; while in the open-hearth furnace, it is absolutely essential in order to obtain the temperature required to operate the furnace. When spoken of in connection with the open-hearth furnace, using producer gas, regenerators mean a gas and an air chamber at each end of the furnace with suitable reversing valves which permit the two chambers at one end of the furnace to be heated by the waste gases while the other two are heating the air and gas entering the furnace.

VARIOUS TYPES AND DESIGNS.

In the early days the checker chambers were built as part of the foundation of the furnace proper, which was a poor design (see Fig. 1). There was always the chance of steel breaking through the bottom of the furnace and filling up the checkers. With the regenerators set to one side of the foundation of the furnace proper, repairs can be made to either without disturbing the other. Another early design (Fig. 2) used horizontal checkers. This had many disadvantages. The full vertical area of the horizontal checker chamber is not heated evenly, because the gases tend to pass through the upper checker openings to the exclusion of the lower openings, while the incoming air seems to seek a different course. This lowers the possible regenerative efficiency since the air is not preheated to its maximum extent. Also the horizontal chamber gives no propelling action at the gases, since the only draught effect obtained is from the uptake to the furnace.

The design for modern furnaces uses vertical checker chambers for both gas and air. It has numerous advantages. The hot air rises naturally in the vertical chamber due to the decreased density caused by the increase in temperature of the air as it rises from the cooler checkers in the bottom rows to the hotter ones on top. This produces a positive pressure on the air which forces it through the port and helps to control the projection of the flame on the bath. This pressure is not so necessary with the gas because it comes from the producers under pressure.

CHECKER BRICKS AND CHECKER DESIGN.

Ordinary (9-in. × 4½-in. × 2½-in.) fire-brick on edge and laid in the ordinary way were among the first bricks to be used in building up checkers. Since 1 in. is about the effective depth in brick for heat absorption and emission, which makes a 2-in. brick the proper thickness, the 9-in. brick came close to being the proper one to use as regards thickness, but it was found that this thickness of brick did not give a stable construction, as the brick was easily upset. With this thickness the salvage is less than for the regular checker block, when the bricks

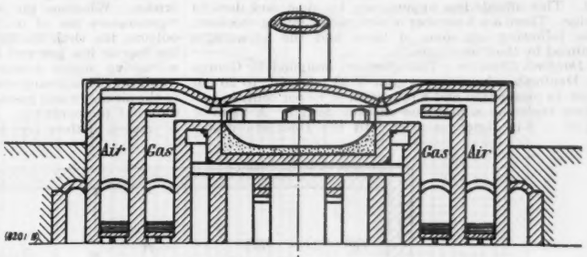


Fig. 2.

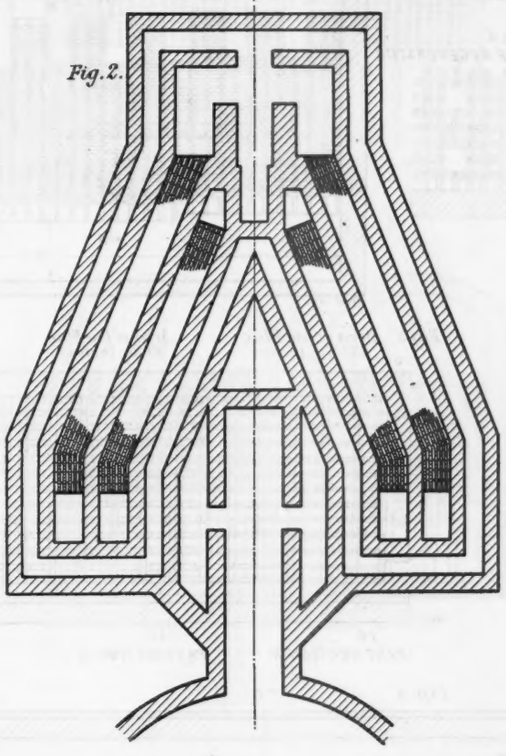


Fig. 1.

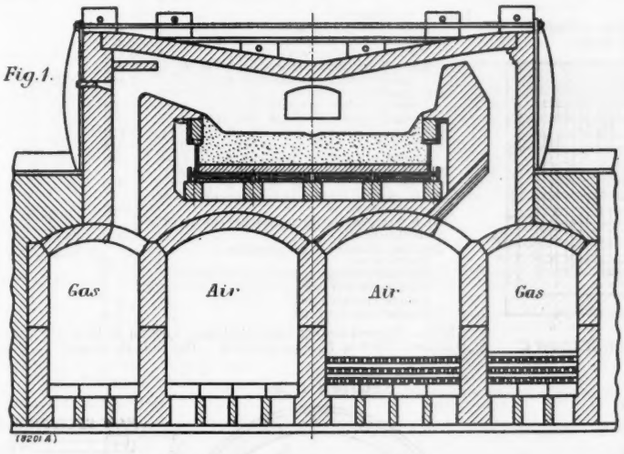
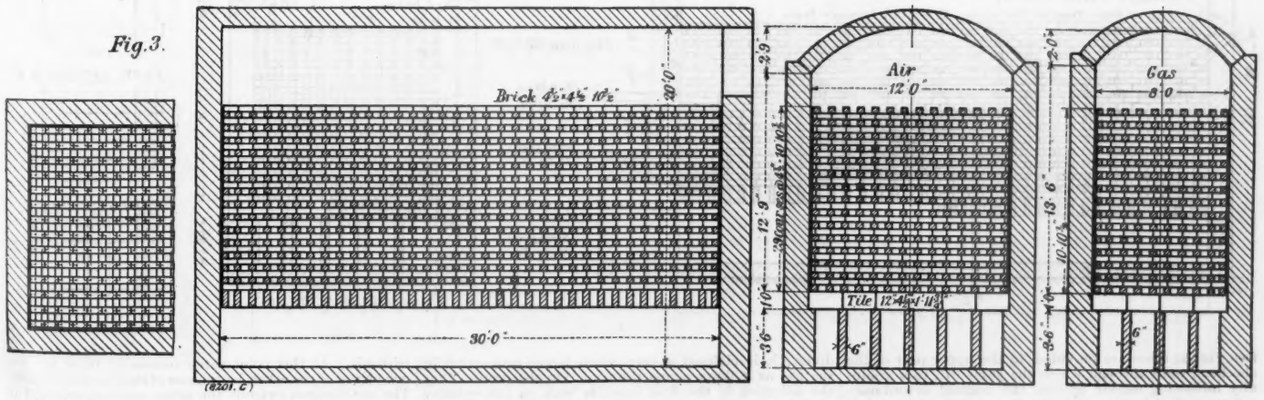


Fig. 3.



Air chamber—	
Number of checker bricks	13,776
Volume above rider walls—cub. ft.	5,277
Volume of checker work—cub. ft.	3,915
Exposed heating surface of brick—sq. ft.	13,811
Volume of checker brick—cub. ft.	1,699
Gas chamber—	
Number of checker bricks	9,510
Volume above rider walls—cub. ft.	3,396
Volume of checker work—cub. ft.	2,610
Exposed heating surface of brick—sq. ft.	9,508
Volume of checker brick—cub. ft.	1,170
Cub. ft. of checker brick per cub. ft. of checker work	0·44
Sq. ft. exposed heating surface per cub. ft. of checker work	3·57
Sq. ft. exposed heating surface per cub. ft. of checker brick	8·12
Ratio air chamber to gas chamber—	
Total volume	1·54
Exposed heating surface	1·5
Volume checker work	1·5
Volume checker brick	1·5
Number checker brick	1·5

* Paper read before the American Iron and Steel Institute, New York. October 25, 1923.

are torn out. To conform with these latter two requirements, it has been thought best to use a checker block 10½-in. × 4½-in. × 4½-in., which gives 6 in. square openings between bricks (see Fig. 3). There is a special shape brick used at one plant which has the top longitudinal corners of the brick, when laid on edge, rounded off. This affords less opportunity for dust and dirt to lodge. There are a number of designs for laying checkers. The following are some of these and the advantages claimed by their inventors.

Danforth Checkers.—This checker, designed by George L. Danforth, who claims a gain of 11 per cent. to 20 per cent. in production and a reduction of 10 per cent. in fuel when replacing a previous checker design. A 2½-in × 4½-in. × 9-in. brick is used. In the Danforth design (see Fig. 4) there are provided, in the upper part of the checkers, wells through which the gases will to a gradually increasing extent by-pass the original or ordinary entrances that become obstructed, and enter the vertical flues by the side entrances at a lower elevation, providing additional entrances to the checkerwork. Placing the brick flat instead of on edge obtains a larger base of contact with the adjacent bricks and a lower centre of gravity.

The two principles incorporated are :—

1. Laying the thin bricks on their sides with adjacent ends apart to obtain the maximum exposed surface with a stable construction.

2. Providing in the upper part of the checkerwork enlarged passageways to by-pass the gases around the original entrances that become obstructed by deposits.

According to Figs. 3 and 4, showing the ordinary design for laying checkers and Danforth's design, Danforth's design has considerably larger heating surface. A large part of the increased heating surface is, however, obtained by placing the adjacent bricks apart, and it is extremely questionable if this additional heating surface is as efficient as the more fully exposed surface.

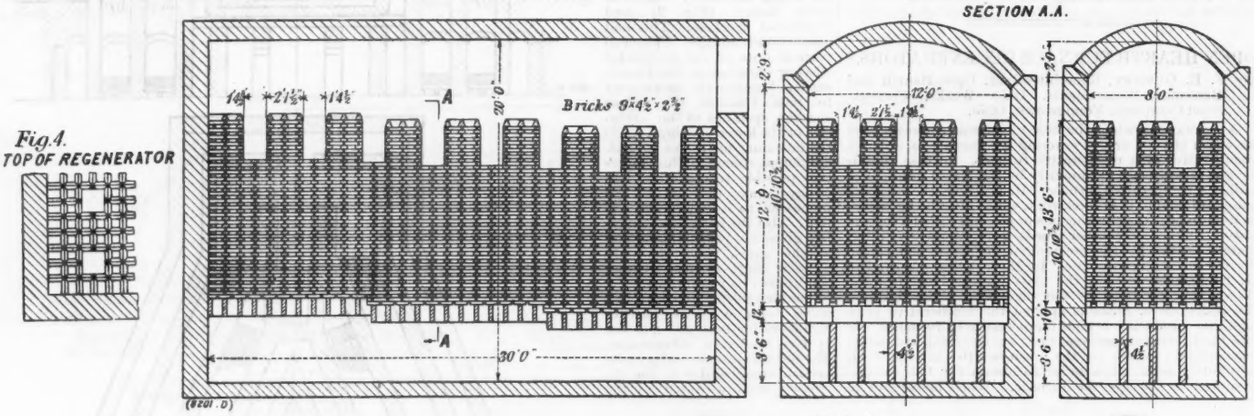
Orth Checkers.—Designed by Frank Orth (Fig. 5), using 10½-in. × 4½-in. × 4½-in. or 9-in. × 4½-in. × 2½-in. bricks. Whereas the vertical flues in the standard regenerators are of uniform cross section from top to bottom, the Orth checker openings are of larger area at the top or hot gas end but are reduced in area in four successive stages toward the bottom where they are smallest. This arrangement gives a more uniform velocity to the air and waste gases, due to their change in volume at different temperatures. The Orth regenerator openings, by reason of their very much larger openings, catch and divert, it is claimed a very much larger proportion of the gas as it flows across the top. On the ground that the adhesion of the dust depends both on the velocity of the gas and its temperature, the deposition of dust on the four or five upper tiers is disproportionately heavy, and here occurs the sharpest check to the velocity of the gas. The claim is that a larger proportion of the dust passes through the flues to the stack and the dust is not burned on the bricks so hard. Since this style makes a hopper-shaped hole it would appear to be harder to clean.

Quarris Type.—In B. D. Quarrie's design, the end of one brick on edge is placed against the middle of another brick on edge, which gives a vertical flue type of checker similar to the one used in blast furnace stoves (Fig. 6). This design prevents the diagonal flow of gases down and across the checkers which obtains in the checkers as ordinarily laid. This design gives stable construction, even when using the thinner brick which gives more exposed surface than the thicker brick. One objection to the stove type is that the gases go through this well without giving up their heat as efficiently as in the other styles of checkers. The remedy for this is to make the chamber deeper and narrower. A convenient brick to use is 13½-in. × 6-in. × 2½-in. The objection to this design is that if the top clogs up, the entire vertical flue is useless. It has, however, a distinct advantage in that it is readily cleaned.

Bonsor-Lorain Type.—This design (see Fig. 7), by Mr. Bonsor of Lorain, Ohio, uses a 15-in. × 6-in. × 3-in. or a 12-in. × 4-in. × 3½-in. brick with the adjacent ends together or 1-in. apart, laid otherwise in the ordinary way. At about the bottom of the bulkhead of the chamber, provision is made for blowing the checkers with air. At this point three courses of brick are run, one on top of the other, lengthwise of the checker chamber. The next course extends the other way, as usual. This makes an exceptionally large horizontal opening the length of the chamber into which an air pipe can be inserted. At Lorain, the checkers are blown about once a week while the furnace is operating with only air going through the checkers. This blowing helps especially with the coke-like deposits which result from using tar as a fuel.

Auxiliary Air Regenerator Chamber.—Thomas H. Kenvin has proposed a design for regenerator chambers which includes one extra chamber, between the usual two chambers, which can be used on either end of the furnace while the regular chamber is off for repairs.

Checkers for Pulverized Coal.—With the use of pulverized coal for fuel in open-hearth furnaces it has been found that special regenerative construction is necessary, in order to take care of the excessive ash content of the



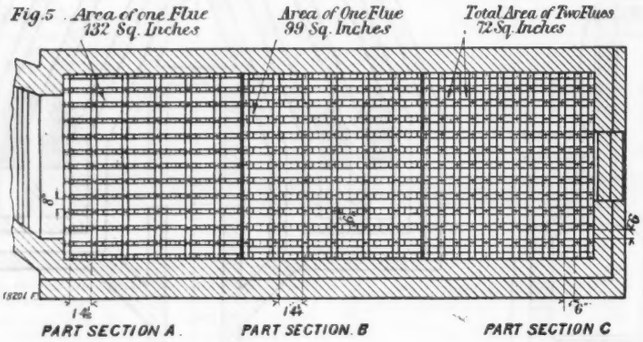
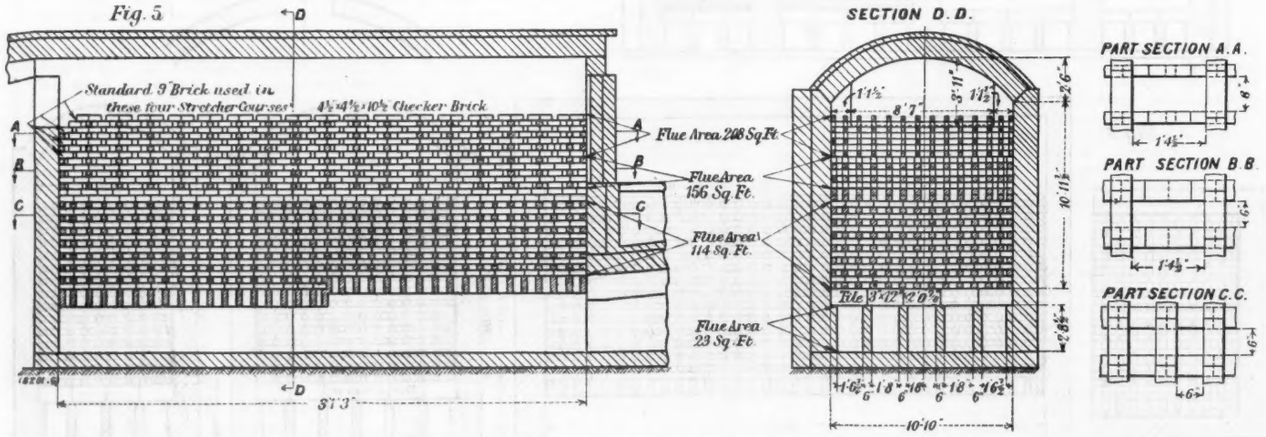


Fig. 5
Area of one Flue 132 Sq. Inches
Area of One Flue 99 Sq. Inches
Total Area of Two Flues 72 Sq. Inches
PART SECTION A.
PART SECTION B.
PART SECTION C

FIG. 4.

Air chamber	
Number of checker bricks	23,900
Volume above rider walls—cub. ft. ..	5,277
Volume of checker work—cub. ft. ..	3,915
Exposed heating surface of brick—sq. ft.	21,282
Volume of checker brick—cub. ft. ..	1,400
Gas chamber—	
Number of checker bricks	16,132
Volume above rider walls—cub. ft. ..	3,396
Volume of checker work—cub. ft. ..	2,610
Exposed heating surface of brick—sq. ft.	14,318
Volume of checker brick—cub. ft. ..	940
Cub. ft. of checker brick per cub. ft. of checker work	358
Sq. ft. exposed heating surface per cub. ft. of checker work	4·95
Sq. ft. exposed heating surface per cub. ft. of checker brick	13·8
Ratio air chamber to gas chamber—	
Total volume	1·54
Exposed heating surface	1·5
Volume checker work	1·5
Volume checker brick	1·5
Number checker brick	1·5

NOTE.—Exposed heating surface includes: 5,038 sq. ft. in air chamber. 3,356 sq. ft. in gas chamber. Due to 1½-in. spacing of bricks.



waste gases. When first tried with regular checker block it was found that openings closed rapidly, and as a result the practice to-day is to use large tile, giving large openings, or some other arrangement using piers or baffle walls. It has also seemed advisable to use removable slag pockets to reduce the amount of ash carried over to the checkers. Some method whereby the ash is deposited before entering checker chambers will assist in the successful use of pulverized coal.

Modern Flue Arrangement for Regenerators.—This design provides for the checker chambers to be built on an angle pointing towards each other, so that the outgoing flues from the checker chambers will be approximately radial to the stack from both chambers. This will also give the easiest flow line and the shortest route for the gases to the stack or waste heat boilers as illustrated in Fig. 8.

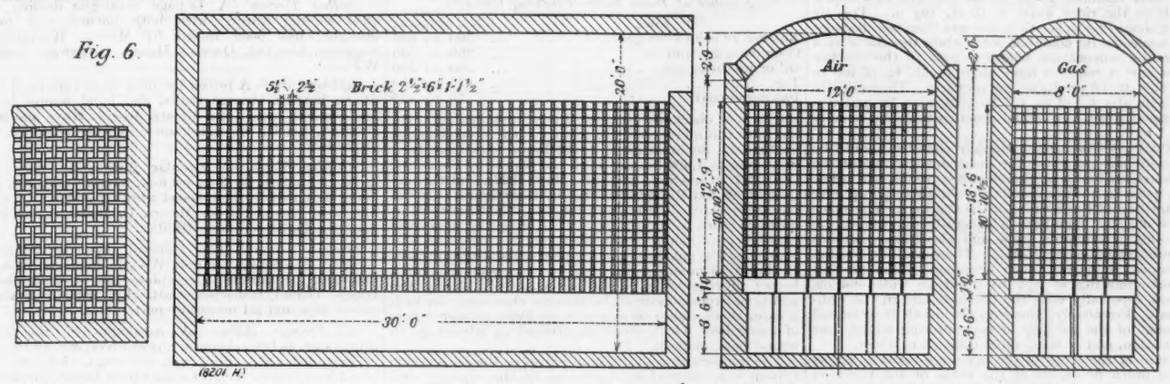
PROPORTIONATE SIZE OF CHAMBERS FOR AIR AND GAS.

The Carnegie Steel Company's Open-Hearth Committee has decided upon the following as the minimum requirements in regard to size of regenerators for a 100-ton producer gas furnace :—

Air Chamber.

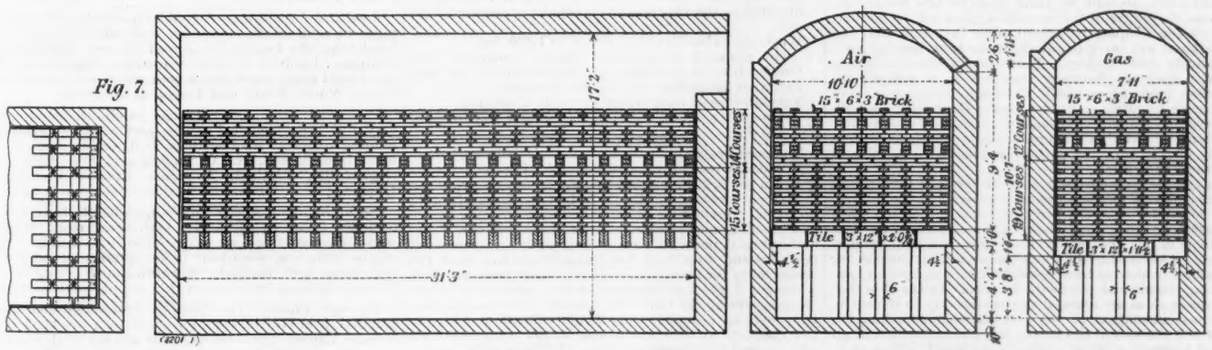
30-ft. × 12-ft. × 20-ft. deep } Entire chamber
68 cub. ft. per ton of steel }
150 sq. ft. of heating surface per ton of steel

Fig. 6.



Air chamber—		Volume above rider walls—cub. ft. ..	3,396
Number of checker bricks	17,617	Volume of checker work—cub. ft. ..	2,610
Volume above rider walls—cub. ft. ..	5,277	Exposed heating surface of brick—sq. ft.	10,914
Volume of checker work—cub. ft. ..	3,915	Volume of checker brick—cub. ft. ..	1,373
Exposed heating surface of brick—sq. ft.	16,370	Cub. ft. of checker brick per cub. ft. of checker work	0·525
Volume of checker brick—cub. ft. ..	2,060	Sq. ft. exposed heating surface per cub. ft. of checker work	4·19
Gas chamber—		Sq. ft. exposed heating surface per cub. ft. of checker brick	7·95
Number of checker bricks	11,745	Ratio air chamber to gas chamber—	
		Total volume	1·54
		Exposed heating surface	1·5
		Volume checker work	1·5
		Volume checker brick	1·5
		Number checker brick	1·5

Fig. 7.



Air chamber—		Volume above rider walls—cub. ft. ..	3,196
Number of checker bricks	5,808	Volume of checker work—cub. ft. ..	1,876
Volume above rider walls—cub. ft. ..	4,085	Exposed heating surface of brick—sq. ft.	8,220
Volume of checker work—cub. ft. ..	2,346	Volume of checker brick—cub. ft. ..	740
Exposed heating surface of brick—sq. ft.	9,814	Cub. ft. of checker brick per cub. ft. of checker work	0·349
Volume of checker brick—cub. ft. ..	907	Sq. ft. exposed heating surface per cub. ft. of checker work	4·07
Gas chamber—		Sq. ft. exposed heating surface per cub. ft. of checker brick	10·8
Number of checker bricks	4,736	Ratio air chamber to gas chamber—	
		Total volume	1·35
		Exposed heating surface	1·20
		Volume checker work	1·25
		Volume checker brick	1·23
		Number checker brick	1·23

Fig. 8.

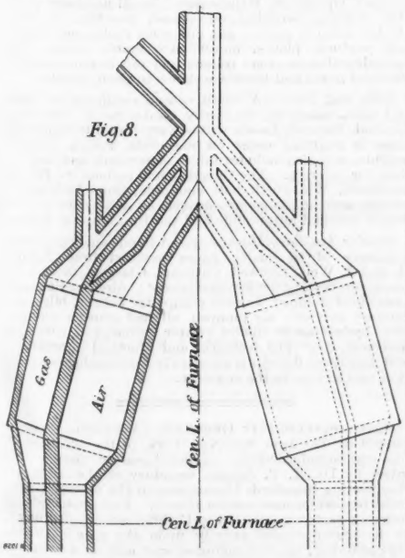


TABLE A.—COMPARATIVE TABLE OF DIMENSIONS OF AIR AND GAS CHAMBERS OF OPEN-HEARTH FURNACES.

	Gary No. 3	Ohio Works Old Style Furnaces.	Duquesne No. 1.	Homestead No. 2.	Schoenberger.
Actual Weight of Heat Poured, Gross Tons	90	77	59·56	54·3	39
FUEL.	Producer Gas.	Producer Gas.	Producer Gas.	Mixture of Natural Gas and Coke Oven Gas.	Natural Gas or Fuel Oil.
AIR CHAMBER :					
Length	31′ 3″	22′ 0″	22′ 0″	19′ 0″	12′ 0″
Width	10′ 10″	12′ 1″	12′ 0″	12′ 0″	7′ 7″
Height	14′ 8″	20′ 11″	11′ 8½″	12′ 2″	11′ 6″
Height of rider walls	2′ 6″	3′ 1″	3′ 3″	2′ 6″	1′ 8″
Average height of checkers above tile	9′ 4½″	14′ 8½″	6′ 0″	9′ 4″	8′ 3″
Number of checker brick in one chamber	11,500	8,500	7,792	7,346	4,158
Size of checker brick	10½″×4½″×4½″	10½″×7″×4″	9″×4½″×3″	10½″×4½″×4½″	9″×4½″×2½″
Opening between checkers :					
Horizontal	6″×4½″	6½″	6″×4½″	6″×4½″	6½″×4½″
Vertical	6″×6″	7″	6″×6″	6″×6″	6½″×4½″
Total volume, cub. ft. per ton tapped	65·2	77·5	62·69	59·5	32·1
Exposed heating surface of checker work per ton tapped, sq. ft.	131·8	156·0	104·5	139·0	87·7
GAS CHAMBER:					
Length	31′ 3″	22′ 0″	22′ 0″	19′ 0″	12′ 0″
Width	7′ 11″	7′ 6″	8′ 0″	9′ 0″	5′ 7″
Height	15′ 3″	20′ 11″	11′ 8½″	12′ 2″	11′ 6″
Height of rider walls	2′ 8″	3′ 3″	3′ 3″	2′ 6″	1′ 8″
Average height of checkers above tile	9′ 4½″	15′ 0″	6′ 0″	9′ 4″	8′ 3″
Number checker brick in one chamber	9,000	5,400	5,320	5,256	3,060
Size of checker brick	10½″×4½″×4½″	10½″×7″×4″	9″×4½″×3″	10½″×4½″×4½″	9″×4½″×2½″
Opening between checkers :					
Horizontal	6″×4½″	6½″	6″×4½″	6″×4½″	6½″×4½″
Vertical	6″×6″	7″	6″×6″	6″×6″	6½″×4½″
Total volume, cub. ft. per ton tapped	45·7	47	37·86	40·9	23·6
Exposed heating surface of checker work per ton tapped, sq. ft.	96·6	100	70·74	113·3	64·5
Cub. ft. of checker brick per cub. ft. of checker work	0·445	0·354	0·353	0·416	0·32
Sq. ft. exposed heating surface per cub. ft. of checker brick	8·4	9·26	11·21	8·37	14·06
Sq. ft. exposed heating surface per cub. ft. of checker work	3·74	3·28	3·95	3·48	4·53

Gas Chamber.

30-ft. × 8-ft. × 20-ft. deep } Entire chamber
46 cub. ft. per ton of steel }
100 sq. ft. of heating surface per ton of steel.

Referring to Fig. 6, it can be seen that the dimensions of the total chamber given allow a height of checker brick above the rider walls of 10 ft. 10½ in. The air chamber should be larger than the gas chamber, because the air comes to its chamber cold, while the gas is at a considerable temperature before it gets to the checker chamber and it requires more than 1 cub. ft. of air to burn 1 cub. ft. of producer gas properly. Theoretically the ratio is about 1·3 to 1. To this must be added a slight excess of air. In actual practice the ratio usually runs 1·5 to 1.

The flues underneath the checker chamber should be of sufficient size to allow for good draught under the entire horizontal area of the chamber, which will allow the hot gases to go down and the cold air to go up over the entire area of the bottom of the checkers. The space used for checker chambers is generally determined by the amount of available space and also from what has been found to be good practice. There are advantages, for instance, in narrow deep chambers which prevent the short-circuiting so apt to occur in wide shallow chambers, especially with the checkers laid in the ordinary way. Practically, however, the depth is restricted on account of the liability of encountering water, cost of excavation, and of being more difficult to clean.

The sum of the areas of the openings between bricks must be much in excess of the areas of the ports on account of the increased resistance offered by the smaller areas, which retard the flow of gases, and because in the run of the furnace these openings become smaller as they gradually choke up with deposits, which form also a rough surface.

On the other hand, the openings cannot be too large or the waste gases will pass through without giving up a maximum amount of their heat to the brickwork, because the centre of the column of gases will be hot and the outside comparatively cool, with the result that the stack gases will carry too much of the heat, leaving comparatively cold checkers. The result is that the design of the openings between checkers is a compromise between large areas easily cleaned, offering minimum resistance to gases, and not allowing the brick to absorb a maximum amount of heat, and small areas which allow the brick to absorb a maximum quantity of heat but are easily choked up, offer greater resistance to gases, and are harder to clean.

In the past, very little attention has been paid to the heat insulation of the checker chambers and the infiltration of air into the checker chambers, due to the stack draught. As has been shown by carefully made heat balances of open-hearth furnaces, there is a large proportion of excess heat in the waste gases entering the checker chambers which cannot possibly be recovered in preheating the air and gas to the furnace. In the case that the waste gases are allowed to pass directly to the stack, the heat insulation of the checker chambers and the flues and the loss in the valves and the infiltration of air is not important, as it makes fairly small difference to the working of the furnace whether the heat is lost by radiation from the checker chambers or in the stack. However, with the increasing use of waste heat boilers for recovering the surplus heat in the waste gases, the insulation of the checker chambers and the prevention of infiltration of air becomes extremely important, and it has been proved in practice that a much larger amount of steam is produced in the waste heat boilers if the checker chambers are properly heat-insulated and if care is taken to close up openings which allow air to be mixed with the waste gases before entering the waste heat boilers. In modern installations, care is also taken to design reversing valves in such a way that the heat and draught losses in these are a minimum. With this type of valve there is less infiltration of air through the boiler setting and a greater economy results. One of the modern methods of insulating checker chambers is to use boiler plate as a barrier on the outside surface, and between this and the brick is placed some heat insulating material. One plant has had the walls and roof of the checker chambers of two furnaces insulated for over a year with no harmful results to the roof of the chambers.

Laboratory experiments have been made on the same brand of bricks to compare the relative heat absorption and emission of new brick, dirty brick, and coated and partly glazed brick. The results of these tests show there was practically no difference among the three kinds tested. Service tests have been made with silica brick in open-hearth furnace regenerators which show that so far as the direct operation of the furnace is concerned there is no advantage thermally or commercially in using silica brick in place of fire-brick. Even if silica brick gave as good results in every way as fire-brick, they would be condemned because the salvage in cleaning is much less, being about 35 per cent. for silica as against 80 per cent. for fire-brick in the air chamber. The life of the checker brick is determined to a large degree by the deposits which collect on them, such as lime, dolomite, ore and other oxides. These deposits, besides choking up the openings, slag with the brick. Different fuels have different effects on the life of the brick. Natural and coke-oven gas are the least damaging; oil and producer gas next, tar next, and powdered coal the worst of all. With powdered coal, there is a considerable deposit of coal ash in the checkers, with tar a coke-like substance.

The gas checkers are not affected as much as the air checkers, as about five times as much of the waste products go through the air checkers, and in addition the gas checkers are not exposed to the oxidizing conditions which obtain in the air checkers. Suction has been tried for cleaning, but was never successful. The best way to clean is with compressed air. After the furnace is taken off, the checkers are either soaked with water or allowed to cool gradually. Then as many rows of brick as are bad are removed and the rest scraped with an iron scraper and blown with compressed air. After the first run on new checkers, very few, if any, are taken out. On the next run more brick are removed before good bricks are found. Some checkers in the lower rows have been in as long as 1,600 heats. Both the papers by Clements, (British Iron and Steel Institute, May, 1922), and the one by Kinney and McDermott show by their figures that the gas regenerators in the furnaces they ran their tests in do little work in preheating. This brings up again the possibility of doing away with the gas checkers and insulating the gas flue from the producers to the furnace. If this were possible, there might be opportunity for a better proportioning of the air chamber, having the additional room occupied by the gas chamber. In such a case, there would be available an even greater excess of waste heat which could be utilized to advantage in waste heat boilers.

Number of Heats before Cleaning Checkers.

Fuel.	No. of heats.
Natural or coke oven gas	300 to 600
Coke oven gas and tar	200 to 300
Oil or producer gas	200 to 300
Tar	175 to 250
Powdered coal	75 to 125

The temperatures at different places in the regenerator system vary somewhat, depending on the capacity and efficiency. However, from the information I have, I believe the following are general limits:—

Waste gases leaving furnace up to 2,900 deg. F.
Waste gases entering air checkers up to 2,600 deg.
Waste gases entering gas checkers up to 2,400 deg.
(This is lower than air on account of the water-cooled port and the relatively small amount of waste gases diverted to the gas checker chamber as compared with air.)
Waste gases leaving checkers up to 1,400 deg.
(In properly proportioned checker chambers this temperature is governed by infiltration of air and radiation losses from the checker chambers.)
Temperature of regenerated air up to 2,400 deg.
Temperature of air entering regenerator 250 deg. to 500 deg.

Temperature drop in regenerated air between reversals depends on the time of reversals, but as a rule is between 250 deg. F. and 500 deg. F.

The regenerators developed in the open-hearth furnace up to the present time are a compromise between theory and practice, with practice the determining factor. From a theoretical point of view it is desirable to use small openings and deep flues, but this is dependent upon the accessibility for cleaning. To do this there must be found a design of checker chambers which permits of better cleaning during the run of the furnace. This can be done by providing cleaning doors which will allow access to the checkers at different places, where compressed air can be used to advantage. Since the stove type checker opening provides a solid well, it is easier to blow the dirt off the top and down through the well. In this case a hole as small as 4½-in. will be sufficient. As stated before, the one objection to the stove type is that the gases go through this well without giving up their heat as thoroughly as in other styles of checkers, and this can be remedied by making the chamber deeper and narrower. With this type chamber we should have a brick composed of material which will more readily absorb and emit heat. Carborundum suggests itself as a possibility except for the few upper tiers, since it might slag there with the deposits which will accumulate on the checkers. Provided carborundum is not durable and is too costly, the best quality of fire-brick can be used. However, the first cost is not the deciding factor, but rather the cost per ton of steel which will be determined to a large degree by the frequency with which the bricks must be torn out. Larger slag pockets will aid in reducing the amount of slag and dust carried over to the checker chambers. Insulation of checker chambers for best efficiency of checkers has proven advisable, and especially so in the case of waste heat boilers. It is also possible to gain thermal efficiency by the insulation of the passageway (fantail) from checker chambers to the slag pockets, and this might be extended to the slag pockets as well. To provide least resistance to the flow of waste gases to the stack or waste heat boilers, a straight line valve should be used with chambers and flues built radially to the stack, thereby reducing the draft and the tendency to greater infiltration.

In other words, what is desired is a narrow, deep, efficient checker with smaller openings between bricks which can be easily cleaned while the furnace is operating, a direct passage for the gases to the stack or waste heat boiler, and a method provided to prevent accumulation of dirt in the checker chambers.

UNITED STATES EXPORTS OF IRON AND STEEL.—A note in *Iron Trade Review*, Cleveland, Ohio, is to the effect that an analysis of exports from the United States reveals that nearly 45 per cent., or 72,762 tons of the total iron and steel exported during August, went to Canada. Cuba was the next largest customer, with 21,878 tons, or 13·5 per cent. of the total, and Japan third, with 14,326 tons, or nearly 9 per cent. Shipments to Canada, England, Spain, Brazil, Mexico and Venezuela increased from the previous month. The most marked decrease was that of the Argentine, which took only 2,200 tons, against 5,300 tons in July, and a monthly average of more than 7,100 tons of iron and steel for the first half of 1923.

CATALOGUES.

Electric Hoisting Blocks.—A new 32-page 8vo catalogue of electric hoisting blocks, showing a great variety of applications to different conditions of service, is to hand from Messrs. Herbert Morris, Limited, Loughborough.

Cooling Towers.—A 44-page catalogue dealing with steel cooling towers, with both natural and forced draught, has been issued by Messrs. Worthington-Simpson, Limited, Queen's House, Kingsway, London, W.C. 2.

Oil Cans, &c.—A priced list of a large variety of cans, fillers, bottles, storage tanks, and hand pumps for oil has come to hand from Messrs. Joseph Kaye and Sons, Limited, Leeds, the well-known specialists in this class of product.

Machine Tools.—A circular illustrating their 7-in. lathe and a 3-ft. by 3-ft. by 8-ft. planing machine, both being designed for high-speed working and hard service, has been received from Messrs. C. Redman and Sons, Limited, Parkinson-lane, Halifax.

Electric Lamps.—The General Electric Company, Limited, Kingsway, London, W.C. 2, have sent us a new catalogue containing a complete list of their electric lamps—Osram, Robertson and Osglim, with illustrations, priced lists and all necessary particulars.

Non-Ferrous Alloys.—A catalogue of non-ferrous alloys such as brass, bronze, nickel silver, &c., in the form of extruded rods, stampings, pressings, chill-cast bars, cored bars, ingots, &c., is to hand from Messrs. McKechnie Brothers, Limited, Rotton Park-street, Birmingham.

Foundry Preparations.—A catalogue of various oils, powders and other preparations for mixing with foundry sand in order to reinforce it or to renew its qualities, has come from the Chemical and Technical Engineering Company, Limited, 11, Pancras-lane, Queen Victoria-street, London, E.C. 4.

Road Reinforcements.—A booklet discussing the advantages of reinforced concrete in road construction is to hand from the British Reinforced Concrete Engineering Company, Limited, 1, Dickinson-street, Manchester. It was issued more especially in connection with the recent Public Works, Roads and Transport Congress.

Structural Steel.—A 122-page handbook containing very full lists, technical tables, and other information relating to rolled steel sections, bolts, rivets, &c., is to hand from Messrs. R. A. Skelton and Co., Steel and Engineering, Limited, Moorgate Station Chambers, London, E.C. 2. The price of this publication is 5*s*.

Motor Engine Cylinder Castings.—The Midland Motor Cylinder Company, Limited, Dartmouth-road, Smethwick, Staffordshire, who specialise in casting small engine cylinders, have sent us an interesting catalogue describing their methods of working and giving a list of many leading firms whom they supply with castings.

Concrete Floors.—The Stanton Ironworks Company, Limited, near Nottingham, have sent us a catalogue of a powder named "Stantonite," for mixing with cement to render concrete floors proof against water and oil and to prevent dust rising. It is stated that the wearing properties of the floors are also improved by the addition of the substance.

Gas and Oil Engines, &c.—A general catalogue containing illustrations and brief descriptions of their various products is to hand from Messrs. Crossley Brothers, Limited, Openshaw, Manchester. Small fixed and portable engines (working on petrol, paraffin, benzine, alcohol, town or suction gas, and other fuels), gas engines and producer plants, motor cars, motor tractors for agricultural work, road rollers, and rail locomotives are the chief items and these are shown in great variety.

Bolts and Nuts.—A small octavo catalogue of bolts and nuts, issued by the Kirby Banks Screw Company, Limited, Beeston, Leeds, will be very useful to engineers, since it contains notes on materials, heads, threads, weights, and also includes tables of strength and instructions for ordering. The threads listed include the British standards, Whitworth bolt and pipe, fine, Association, square, automobile, acme and vee, as well as the United States bolt and automobile and the International metric.

Marine Auxiliary Machinery.—A handsomely produced catalogue of 80 quarto pages received from Messrs. G. and J. Weir, Limited, Cathcart, Glasgow, deals with plant for heating boiler feed water; direct-acting and turbo-feed pumps; various pumps for ballast, bilge and sanitary service; air pumps; oil fuel transfer pumps; the hydrokineter boiler water circulator corrosion detectors, &c. The technical and practical information and illustrated descriptive matter in this catalogue render it of real service to the engineer.

STANDARDISATION IN GERMANY.—A striking example quoted by *The Iron Age*, New York, of the efficiency of national standardisation as developed in Germany is given by Dr. A. P. Agnew, secretary of the American Engineering Standards Committee, in the case of a rush order for 200 locomotives for Russia. The production of different parts was allotted to 17 different manufacturers, to be manufactured strictly upon the plan of interchangeability, no one manufacturer making a complete locomotive. No serious practical difficulty was encountered in filling the order. The inspectors made a particularly striking test of the feasibility and accuracy of the plan by ordering a complete locomotive to be assembled from parts chosen at random from the parts furnished by the 17 manufacturers. It proved to be ready for service immediately after assembly without necessity of dismantling for readjustment.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

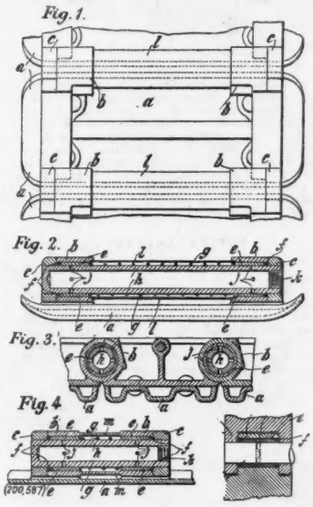
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

MOTOR ROAD VEHICLES.

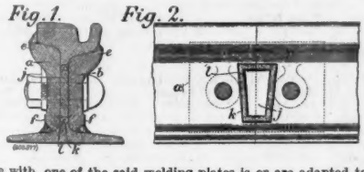
200,587. G. J. Rackham, Charlton, London. Endless Tracks for Vehicles. (5 *Figs.*) April 13, 1922.—The invention relates to endless tracks having shoes pivoted together by pins passing through bearings on links fixed to the shoes. In the illustrated arrangement, each shoe *a* has links *b* and lugs *c*, the link of one shoe fitting inside the lugs of an adjacent shoe. Floating bushes *e* are inserted into the links *b* and have at their outer ends washers *f* which are held in contact with the lugs *c* by



a spring *g* mounted between the bushes *e*. The shoes *a* are connected together by a hollow pin *h* which passes through the lugs *c* and bushes *e* and is provided with holes *j* through which grease passes to the bushes. Grease is inserted into the pin *h* through a hole at one end which is closed by a plug *k*. In Figs. 1 to 3, the spring *g* is enclosed by a tube *l*, but in Fig. 4 the links *b* are cast in one piece and are connected together by a tubular portion *m* which takes the place of the tube *l*. (*Sealed.*)

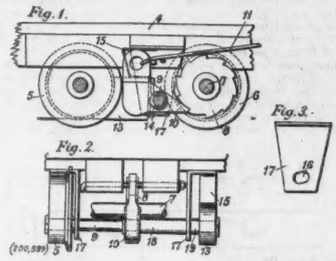
RAILWAYS AND TRAMWAYS.

200,377. S. Butler, Blackpool. Railway and Tramway Rail Joints. (5 *Figs.*) July 19, 1922.—According to the invention, the railway, tramway or like rail joint comprises welding plates *a*, *b* provided with flanges *e*, *f* along the upper and lower edges thereof respectively adapted to be welded to the head and the flange portions of the rails, and a relatively small insertion or filling piece or pieces separate from, or formed in



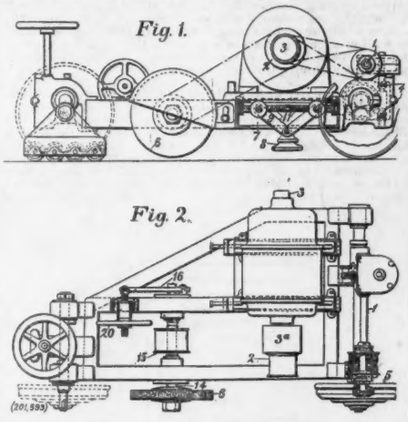
one with, one of the said welding plates is or are adapted to be welded within an opening or openings *k* formed in the web or webs of one or both of the rails adjacent the joint. The openings *k* are of quadrangular or other suitable shape, and are preferably of slightly larger size than the insertion or filling pieces *j*, so as to leave around the latter a space or channel for the welding material *l*. (*Sealed.*)

200,589. W. Fraser, Aberdeen. Vehicle Brake. (3 *Figs.*) April 18, 1922.—The invention relates to self-acting vehicle brakes of the kind in which a pawl mounted to move with an axle carrying a brake, rides over a ratchet member when the vehicle is moving forward and is engaged by the ratchet member when the vehicle reverses, the catch or pawl thereby moving the axle to actuate the brake. The bogie 4 runs on front wheels 5 and rear wheels 6, the latter being fixed upon an axle 7 upon which is fixed a ratchet wheel 8. Free to oscillate upon a cross-shaft 9 is a pawl 10 which engages the ratchet wheel either by gravity or under the action of a spring. The pawl 10 may be rocked to disengage it from the ratchet wheel 8, and thus enable the bogie to be reversed, by means of a pull-rod 11 connected to the pawl 10. Each end of the cross-shaft 9 supports a brake block 13 secured to the cross-shaft by a strap 14. Each brake block 13 is also supported from the underside of the bogie by a flat bent spring 15 which serves to throw the brake block clear of the bogie wheel when the ratchet wheel 8 exerts no pressure on the pawl 10. The shaft 9 serves to transmit to the brake blocks the thrust applied by the ratchet wheel 8 to the pawl 10 when the motion of the bogie reverses, whilst the spring 15 throws the brake blocks clear of the wheels when the reverse motion ceases. The forward motion of the bogie also tends to make the brake blocks lag behind and thus clear the bogie wheels. The shaft 9 is movably supported in slots 16 in angle brackets 17, which are secured to the underside of the bogie, the slots 16 acting as guides for the shaft and allowing it to move the brake blocks up against the wheels of the bogie. 18 and 19 are distance sleeves on the shaft 9 between one of the brackets 17 and the pawl



10 and brake block 13 respectively. Instead of being mounted on a cross-shaft 9, the pawl 10 may be pivoted to a block or fork at one end of a longitudinal reciprocatory brake rod, the other end of which is connected to the brakes, the block or fork serving as an abutment for one end of a spring on the brake rod, the other abutment consisting of a bearing for guiding the brake rod during its reciprocatory movement, this bearing being secured to the vehicle body or frame. (*Sealed.*)

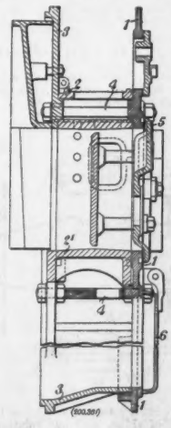
201,593. T. Brooks, London, and The Woods-Gilbert Rail Remodelling Company, Limited, London. Rail-Dressing Machines. (2 *Figs.*) May 2, 1922.—The invention relates to light types of motor-driven rail-dressing machines running on three wheels. A shaft 1 is mounted at the rear of the frame of the truck. This shaft 1 is driven from a pulley 2 on the motor shaft 3 and then drives through gearing 4 the tractor wheels 5, so that the motor not only operates the grinding wheel or cutter-wheel 6, but also propels the truck. In addition, lifting and turning mechanism 7 is provided so that the tractor



wheels can be raised from the track by hand-operation when the machine is to be moved from the rails, this enabling the machine to be fitted with road wheels. The lifting and turning mechanism comprises a foot 8 and a superposed hood on which are articulated links 9 fitted to mesh with a shaft 11 formed with right and left-hand screw threads. The shaft 11 is turned by hand. The grinding wheel 6 is fast on a spindle 14 fitted with a belt pulley 15 driven direct from the pulley 3a. The inner end of the spindle 14 is grooved to engage a clutch lever 16 operated by hand wheel 20. (*Sealed.*)

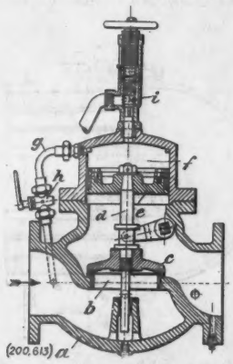
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

200,361. James Howden and Co., Limited, Glasgow, and C. W. Hume, Glasgow. Furnace Fronts. (11 *Figs.*) July 12, 1922.—The invention relates to furnace fronts of the type



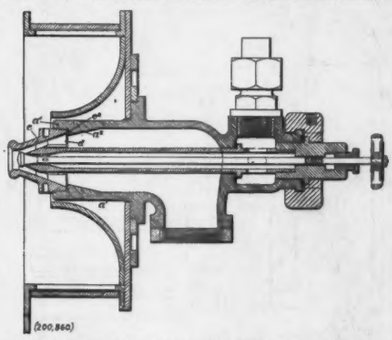
built up in sections comprising separable outer and inner plates and an intermediate body piece clamped together and a removable portable sill at the firing entrance supported between the plates. According to the invention, each of the main furnace units, that is, not only the outer plate and inner plate, but also the body piece, consists of a single distinct casting, the body piece being in the form of an integral archway having a hollow roof and having at the base a gap adapted to be closed by the sill. The outer plate 1, the body piece 2 and the inner plate 3 of the furnace front constitute separate castings, being clamped together by bolts 4. The base portion 21 is removable and supported between the plates 1 and 3. The inner plate 3, which is attached to the furnace, is integral with the metal forming the ash pit, which fits into a recess in the outer plate 1. The outer plate 1 carries the furnace door 5, the ash pit door, &c. The outer plate 1 and the inner plate 3 are made in such a manner that the body piece 2 can engage conveniently with them, the body piece, which is formed as an integral archway having a hollow ported roof, forming a distance member between the plates. (*Sealed.*)

200,613. R. A. Blakeborough and H. Tart, Brighouse. Automatic Relief Valves. (3 *Figs.*) April 27, 1922.—The invention has reference to valves designed to open automatically on a determined inlet pressure being attained or exceeded, and to close again automatically when the pressure has been relieved to the desired extent. *a* is the valve casing having the seat opening *b* controlled by valve *c*. The spindle *d* of the valve has secured upon it a piston *e* working in a cylinder *f* provided in the upper part of the casing. A pipe *g*, including a controlling stop cock *h*, connects the inlet side of the casing with the space in



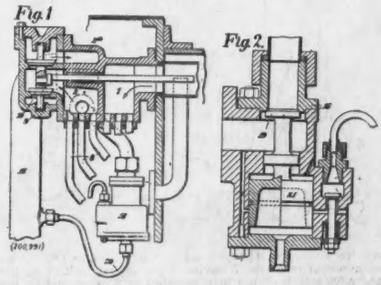
the cylinder *f* above the piston *e*. In the top of the cylinder *f* there is provided an adjustable relief valve *i*. This valve *i* is set at the desired pressure at which the surplus steam is to be allowed to pass. When the pressure in the cylinder *f* rises to such a point that the relief valve opens, the escaping steam passes through the pipe shown to the outlet side of the valve. The pressure above the piston *e* is thus maintained at the desired relief point, whilst the inlet pressure builds up beneath the valve *e* and raises the same. When the inlet pressure falls again to below the determined point the valve *i* closes and the inlet pressure acting on the upper side of the piston *e* causes the valve *c* to close. (*Sealed.*)

200,860. A. Laing, Newcastle-on-Tyne. Gaseous or Liquid Fuel Burners. (6 *Figs.*) January 4, 1923.—The invention relates to gaseous or liquid fuel burners. The invention is characterised by the fitment between the nozzle and the burner body of one or more spacing washers which determine the



position of the nozzle in relation to the tapered end. *a* denotes the body of the burner which is internally threaded at the front end *a1* for the reception of the adjustable nozzle-piece *e*, and is tapered at *a2*, the tapered portion terminating in a shoulder which serves as an abutment for the washer e^3. The cone *d* is held in position by the washer e^3. (*Sealed.*)

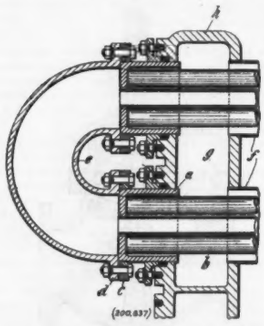
200,991. A. Jouanno, Hove (*C. G. Jouanno, Nairobi, Kenya Colony*). **Steam Superheaters.** (4 *Figs.*) June 7, 1922.—A steam superheater, in accordance with the invention, com-



prises a header 1 in connection with the steam space of the generator, herein called the distributor header, a second header 2 in connection with the apparatus in which the superheated steam

is utilised, herein called the collector header, and a number of superheater tube elements 8 connecting the headers. A casing 9 with regulator valve 10 is mounted on the collector header 2 and controls the emission of steam therefrom. A superheated steam supply pipe 15 is in connection with the regulator valve casing, and a circulating valve 16 connects automatically the collector header 2 with the steam space of the generator on the closing of the regulator valve 10. The circulating valve comprises a valve casing 16 connected with the collector header and the steam space of the steam generator. Valve 19 controls the connection. a piston 21 actuating the valve 19. A connection 20 is made below the piston 21 with the superheated steam supply pipe 15. The collector header is divided into two portions or chambers 2, 2a, connected together through the regulator valve casing 9, the one chamber 2 being in connection with the superheater tube elements, and the other 2a with the superheated steam supply pipe 15. (*Sealed.*)

200,637. Thomas Piggott and Co., Limited, Birmingham and J. R. Marsden, Roundhay, Leeds. Heat Exchangers. (2 *Figs.*) May 10, 1922.—The invention refers to heat exchangers, coolers and the like of the type in which a number of tubes or vessels pass through a larger tube or vessel so that liquids, gases, vapours or other bodies of either the same kind or different kind may pass through the tubes or vessels, either in parallel like directions or in opposite directions. In accordance with the invention, the ends of the various inner tubes of the system are secured to expansion sleeves which are arranged through the outer wall of the headers or connection chambers of the outer



pipes, and these sleeves are jointed to connection pipes outside the headers so that there is no relative movement between the inner pipes and their connection pipes as they move together under expansion or contraction. The expansion member comprises a sleeve *a* into the end of which the inner tubes *b* are expanded. This is provided with an external flange *c* at its outer end for securing it to the flanged end *d* of a semi-circular connection pipe *e* for joining up the inner sets of tubes into serpentine coils throughout the apparatus. The outer tubes *f* are connected up together in series or serpentine fashion by arranging the ends to open in pairs into chambers *g* arranged in staggered relation in two headers or columns *h*. (*Accepted July* 25, 1923.)

198,231. A. Jouanno, Hove (*C. G. Jouanno, Nairobi, Kenya Colony*). **Superheaters.** (4 *Figs.*) June 21, 1922.—In superheaters and superheating arrangements, in accordance with the invention, steam at boiler pressure is circulated through the superheaters when the engine is not at work, and for this purpose, as

Fig. 1

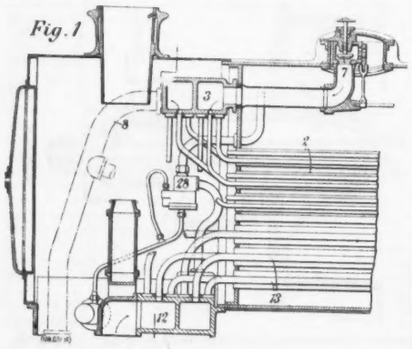
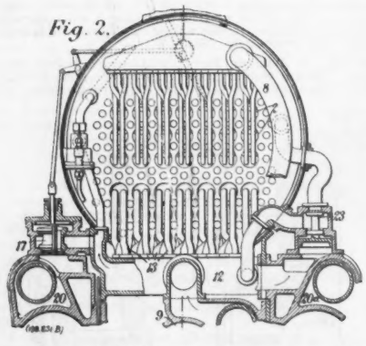


Fig. 2.



applied to a compound steam engine, there is employed a high-pressure steam regulator 7 having a permanent leak or by-pass to the inlet side 3 of the first superheater 2, a second or low-pressure regulator 17 between the high-pressure cylinder or cylinders 9 and the low-pressure cylinder or cylinders 20, 20a. A valve 23 controls a connection between the high-pressure steam supply 8 and the inlet 12 of the second superheater 13 and a valve 28 connects the outlet of the second superheater with the boiler, the valves being maintained closed by steam that has done work in the high-pressure cylinder or cylinders. (*Sealed.*)

201,309. L. J. Steele, Portsmouth, E. F. Kent, Portsmouth, and G. A. Madden, Southsea. Furnace Grates. (3 *Figs.*) May 17, 1922.—The invention relates to stokers of the travelling grate type in which longitudinally or transversely-disposed grate bars are carried within so-called cars or frames that are transversely arranged in parallel lines and are removable and secured to transverse bars connected together to form an endless conveyor. A series of pairs of links *a* pivoted upon spindles *b* carry transverse cap or frame supporting bars *c*. Each of the bars *c* supports a series of the caps or frames *d* in which are integrally formed the grate bars *e*. Each frame *d* is provided with a lug d_1 extending downwards, in which is formed a hole for the reception of a bolt *f* by which the frame is

Fig. 1.

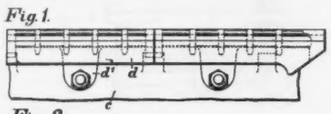
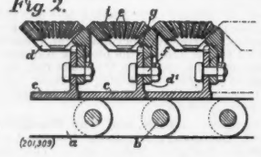
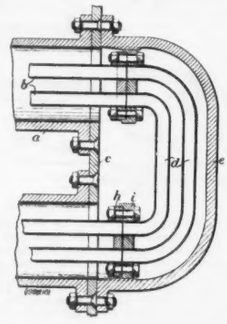


Fig. 2.



secured in position upon the supporting bar *c*. The latter is formed with upstanding lugs *g* to fit within recesses formed in the lower edges of the depending portions of the adjacent frames *d*. Each frame *d* is formed with a series of grate bars *e* extending longitudinally, the bars being of a cross-section increasing from the lower edge to the upper surface and being disposed in such manner that the interstitial spaces *i* between the adjacent bars also gradually increase in width from the bottom to the top. By reason of what may be termed the radial disposition of the grate bars in each frame, the air passing through the grate from beneath is well diffused or distributed in a fan-wise manner through the fuel. (*Sealed.*)

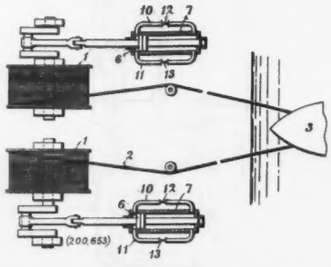
199,210. Blair, Campbell and McLean, Limited, Govan, and A. Blair, Govan. Evaporators. (4 *Figs.*) May 4, 1922.—The invention has reference to apparatus for evaporating, distilling, heating or cooling fluids of the type wherein the fluid is circulated through nests of tubes enclosed within outer casings, and the heating or cooling fluid is circulated through the casing or *vice versa*. In an apparatus of this type, according to the invention, each nest of tubes *b* is enclosed within an outer casing *a* secured to end plates *c*, the tubes passing freely through openings



in the latter and their extremities connected by suitable bent or curved connections *d* to the tubes forming the adjacent nest, the connections being enclosed within a dome or cover *e* secured to the end plates. The extremities of the tubes *b*, and also those of the bent connections *d*, are secured to tube plates *h*, *i*, respectively, secured together within the dome or cover *e* by any convenient means. For example, the one plate *i* may be recessed and the other *h* adapted to fit and be secured within the same by bolts and nutsso as to form a tight joint. (*Sealed.*)

SHIPS AND NAUTICAL APPLIANCES.

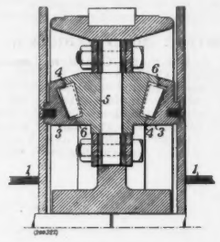
200,653. M. Share, Sunderland, C. Kidd, Sunderland, J. W. Wood, Sunderland, and W. Ransom, Barrow-in-Furness. Launching of Ships. (4 *Figs.*) May 25, 1922.—



The invention has reference to means for use in or in connection with the launching of ships, and has relation in particular to means which, when the ship has entered the water, shall apply a braking action to check or assist in checking the way on the ship. The means for the purpose specified in accordance with the invention comprise cable winding drums 1 on which cables 2 connected with the ship 3 are wound. Cylinders 7 with pistons 6 therein are connected with and driven by rotation of the drums. Valve-controlled fluid connections 10, 11 are placed between the ends of each cylinder, each connection having therein a valve 12 or 13 which permits flow of fluid in one direction only. (*Sealed.*

TEXTILE MACHINERY.

200,322. James Scott and Sons, Limited, Dundee, and A. Mudie, Dundee. Warp Beam Braking Devices. (1 *Fig.*) June 6, 1922.—The invention relates to braking devices for warp beams of looms for weaving of the type in which there is located between the half beams a differential gear, the main spur wheel of which meshes with a spur wheel on a countershaft which is fitted with a drag and with means for effecting rotation by the weaver. The invention is primarily characterised by the feature that the bevel wheels 3 of the differential gear are each rigidly secured to the inner end of a half beam 1 so as to form in effect an integra



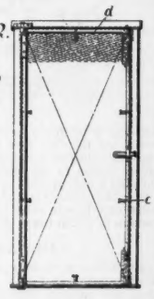
part thereof, the arrangement being such that the gear elements of the differential gear are brought into mesh as soon as the half-beams are properly located. A feature of the invention is the disposition on each bevel wheel 3 of a conical track 4 which lies on a surface of revolution containing the pitch line of the wheel 3, and the disposition on each idler bevel wheel 5 of a conical track 6 which lies on a surface of revolution containing the pitch line of the idler wheel. The arrangement is such that the tracks 4 of the bevel wheels 3 ride on the tracks 6 of the idler bevel wheels 5, so that correct inter-meshing of the wheels is ensured without skilled adjustment. (*Sealed.*)

MISCELLANEOUS.

200,571. H. R. Sankey, Ealing, London. Fire-Resisting Doors and Screens. (2 *Figs.*) April 11, 1922.—The invention relates to a fire-resisting door or movable screen intended to form part of the wall of a furnace or other receptacle capable of withstanding the temperature of molten steel. According to the invention, there is arranged within the wall of the furnace or other receptacle, a door or movable screen consisting of a frame *a* built up of channel section or T-section bars, and within this frame there is mounted a layer or layers *d* of metal mesh, such as expanded

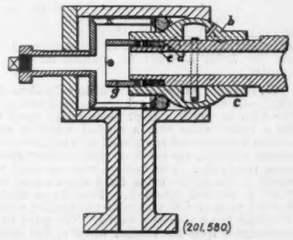
Fig. 1.

Fig. 2.



metal or wire netting, held in position by lugs or keys arranged at suitable distances on the channel section or T-section bars. The frame formed by these bars is held together at the corners by bent metal plates *b* riveted to the inner sides. The frame *a* is filled with a non-conducting heat-resisting compound capable of withstanding the temperature of molten steel, for example, the composition known by the registered trade mark "Herculite," so as completely to embed the binding plates, the lugs and the meshing. (*Sealed.*)

201,580. W. Mycock, Whitworth, near Rochdale. Drying Machines. (4 *Figs.*) February 1, 1922.—The invention relates to the bearings or "doll heads" of the cylinders of drying machines in which an interior non-rotary sleeve of spherical contour is fitted to receive and form a bearing for the trunnion of the cylinder held in position within the doll head by a cage and screw. According to the invention, the spherical sleeve



bearing *b* is extended at the rear end and the free end of the trunnion *c* is also extended providing a recess within the sleeve to receive packing *e*, and a shoulder *d* against which the packing is compressed by a hollow nut or ferrule *g* screwed on to or into the rear end of the spherical sleeve *b*, thereby forming a packing gland and steamtight joint between the trunnion and the spherical sleeve bearing. (*Accepted August* 15, 1923.)